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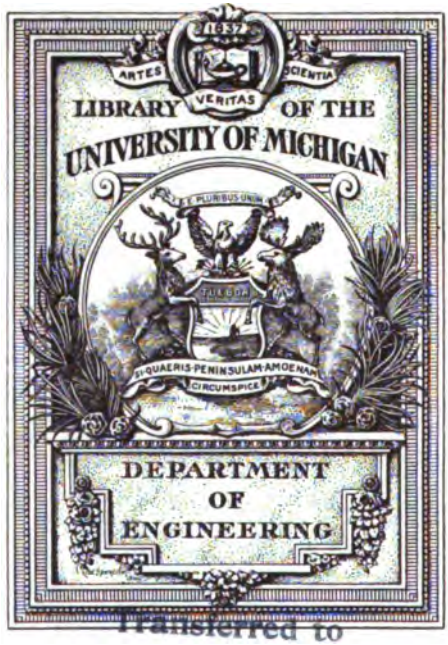

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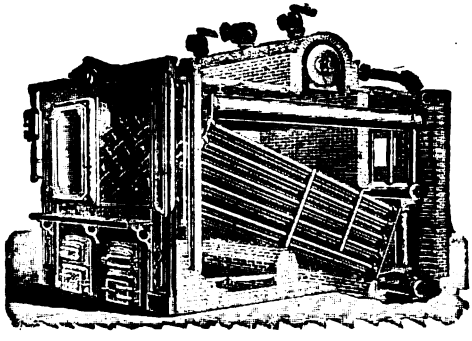

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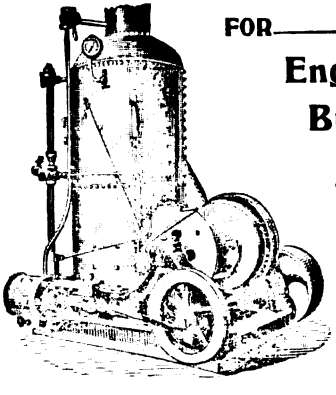

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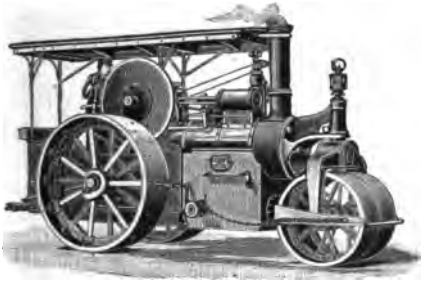

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ANNUAL CONVENTION, 1895.

PAPERS AND DISCUSSIONS.

THE WASTE AND CONSUMPTION OF WATER.

BY G. S. WILLIAMS,

Civil Engineer of Detroit Water Works.

The providing of a sufficient supply of water for the increasing demands of an increasing population is a problem that is now attracting the attention of many of our larger municipalities, and is one that in many cases is becoming more difficult of solution each year, and the time is approaching when most rigid economy will have to be exercised in the use of water unless some unforseen sources of supply may be developed. Brooklyn for years has been each summer close on the verge of a water famine; in Philadelphia the demand in certain localities so far exceeds the supply that it has been impossible to maintain a reasonable pressure; Boston in 1892 estimated that the sources of supply then utilized could only provide for her population for the next ten years. Under such circumstances the prevention of waste is of paramount importance, and in all cases the purely financial aspects of the matter entitle it to most careful consideration.

To reach a fair appreciation of the subject of waste we will consider it in its bearings to the systems now in operation in

156358

various American cities. To those taking their supplies from subterranean sources, or from inland lakes and streams dependent for their flow upon the rainfall over comparatively limited areas, and hence must carefully guard such supplies from contamination by increasing populations and especially from destruction by the denuding of forest lands, the subject is of higher importance than to the cities more fortunately situated on the great lakes or our large rivers where the worst to be anticipated is additional expenditure for pumping and the cost of increased capacity of intake, distribution and machinery, with at most a settling basin or filter plant added.

Brooklyn is our only large city dependent upon a subterranean supply, although in Europe, especially in Germany, this source of water is very extensively developed. The supply obtained at Brooklyn is from the sands underlying the surrounding country through which the rainfall on the interior of Long Island flows to the sea. Since the water-bearing sands are not overlaid with impervious strata a contamination of the supply is liable to occur as the territory from beneath which it is taken becomes populated, so that the solution of the problem of a water supply there requires the prevention of the settlement of large portions of Long Island, or the establishment of artificial purification. In either case the reduction of the quantity consumed is of inestimable consequence. To Boston with works already costing $24,000,000, expending yearly from $20,000 to $25,000 in caring for the sewage of neighboring cities to protect the water supply which six years hence will be insufficient, with the prospect of increasing that supply if at all only at enormous expense, the question is of not less importance.

One would naturally suppose that in these cities at least some means would have been found to decrease the quantity used per inhabitant, or certainly to prevent its increase, but neither here nor anywhere else in America do we find a case of continuous per consumer reduction, as will be seen from the following:

TABLE OF DAILY PER CAPITA CONSUMPTION IN GALLONS.

City.	Population, 1890.		1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.
Baltimore	433,547		95										95			95	
Boston	446,507	Cochituate							74.3	80.7	88.0	82.7	82.5	89.3	95.3	107.5	
		Mystic							72.5	72.7	76.5	70.4	70.6	74.7	78.6	84.4	
Brooklyn	804,377									58	61.5	60.6	60	62.3	68	75	
Chicago	1,098,576		112					116					126	135		146.8	150
Cincinnati	296,309										117					124.3	
Cleveland	261,546	Per consumer	145	162	136	137	138	139	137	140	130	104	129	136	143	158	
Detroit	205,669	Per consumer	130	146	131	161	155	171	180	207	218	184	163	153	148	158	147
Louisville	161,005	Per consumer	88	109.8	90.2	95.5	98.3	104.8	104	103.9	101	98.7	99.8	98.1	103	104.3	
Milwaukee	204,150		106	107	111	105	98	101	107	114	103	101	109	111	101	106	
New York	1,513,501		77	77	78	76	79	84	85	86	85	84	90	91	90	93	95
Philadelphia	1,046,252					75	74	72	80	89	100	110	131	140	143	150	160
Providence	122,043					34										57	
St. Louis	460,357		72								71						
Washington	229,296													209.9		215	

While the information in this table from cities having a gravity supply may be open to some question the tendency to a steady increase in the per capita usage of water is clearly shown. In Brooklyn the increase during 1893 appears to have been over ten per cent; in Boston the increase has been continuous as also in Providence. New York, Philadelphia and Chicago; Cleveland, Louisville and Milwaukee show fluctuations, and Detroit shows a steady increase until 1888, since which time strenuous efforts have been made to prevent waste, and as a result the per capita consumption has been reduced over twenty-five per cent, although it is still at an abnormally high figure.

The question, "What is to be considered a legitimate per capita consumption," does not appear to admit of a ready answer if we are to judge from the above table. Of the cities there shown, in Providence, New York and Boston meters are very extensively used; in Philadelphia and Chicago there are comparatively few.

The difference between American and European cities will be readily seen by comparing the foregoing with the following table, which latter is mainly taken from a paper before the Boston Society of Civil Engineers by Mr. Allen Hazen, chemist of the Massachusetts Board of Health:

City.	Population.	Gallons daily, per capita.	City.	Population.	Gallons daily, per capita.
Warsaw	500,000	12	Frankfort	186,000	36
Leipsic	360,000	15	London (Seven Companies)	5,030,000	38
Amsterdam	515,000	20	Munich	300,000	38
Dresden	280,000	21	St. Petersburg	960,000	40
Breslau	335,000	22	Cologne	255,000	45
Vienna	1,000,000	23	Paris	2,500,000	53†
Manchester	963,000	24	Hamburg	583,000	53
Magdeburg	200,000	24	Rotterdam	240,000	54
Liverpool	815,000	27	Dublin	327,000	55
Berlin	1,606,000	29*	Glasgow	794,000	64
Bradford	364,000	33	Budapesth	500,000	65
London (Kent Company)	460,000	35			

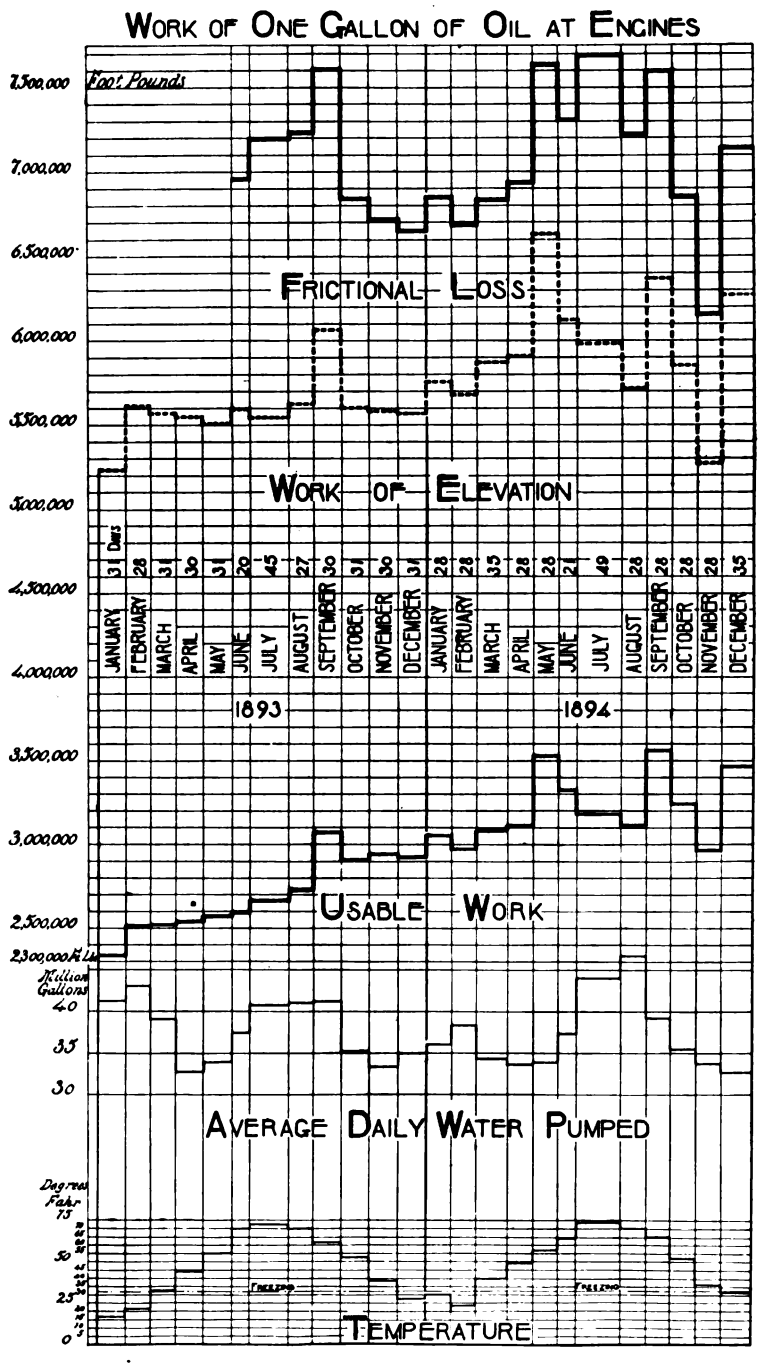
* Nineteen gallons by city and 13 gallons by other supplies.
† Twenty-one gallons domestic.

Commenting on the facts set forth in this table Mr. Hazen says that in some instances the small European consumption may be accounted for by the absence of water closets, or by the fact that the entire population do not have flowing water in their apartments; and furthermore that very little provision is there made for water to extinguish fires, the entire quantity used by the Berlin fire department during 1893 being only about 100,000 gallons, and this exceeded the quantity so used in any other German city except Hamburg. Continuing, he says that in the former city eighty-six per cent of all the water pumped by the city is accounted for by meters and paid for, leaving only fourteen per cent for street cleaning, sewer flushing, fire extinguishing, public fountains and leakage. But according to Baumeister a further supply of thirteen gallons per capita is furnished from other sources which does not appear to be included in the above figures.

The committee recently appointed to consider the necessary supply for the city of London decided that forty-two gallons was a maximum and very liberal allowance for all domestic and manufacturing purposes.

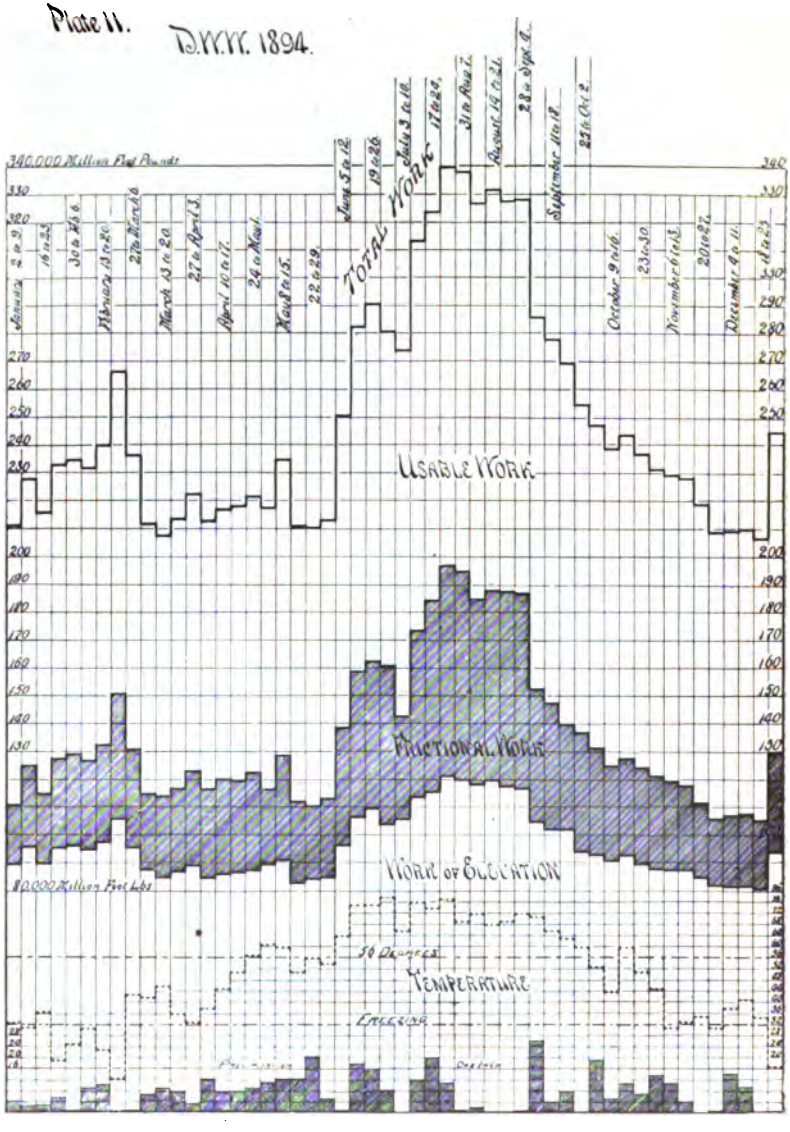
It is the intent of this paper to point out the causes which tend to increase consumption, and as far as may be to indicate the courses to follow in its reduction. As in addition to the data gathered in other cities there will be presented some results of observations in Detroit, chiefly in the form of diagrams, it may be well to digress from the strict confines of the subject under discussion to describe the system of records from which many of these results are deduced. So far as I am aware no other city is keeping records of work and pressure on so extended a scale as Detroit. Through the courtesy of the fire department there are located about the city in various fire engine houses nineteen pressure gages connected with our mains. These with the gage at our own office and the gages at the pumping station make twenty-one locations from which pressures are read, and are shown by circles on the accompanying map of the system. Each gage is taken as representing a

Plate 1.


WORK OF ONE GALLON OF OIL AT ENGINES
7,500,000 Foot Pounds
7,000,000
6,500,000
6,000,000
5,500,000
5,000,000
4,500,000
4,000,000
3,500,000
3,000,000
2,500,000
2,300,000 Ft. Lbs.
FRICTIONAL LOSS
WORK OF ELEVATION
USABLE WORK
Days
JANUARY 31
FEBRUARY 28
MARCH 31
APRIL 30
MAY 31
JUNE 20
JULY 45
AUGUST 27
SEPTEMBER 30
OCTOBER 31
NOVEMBER 30
DECEMBER 31
1893
JANUARY 28
FEBRUARY 28
MARCH 35
APRIL 28
MAY 28
JUNE 21
JULY 49
AUGUST 28
SEPTEMBER 28
OCTOBER 28
NOVEMBER 28
DECEMBER 35
1894
Million Gallons
40
35
30
AVERAGE DAILY WATER PUMPED
Degrees Fahr.
75
50
25
0
TEMPERATURE

district whose boundary and area is determined by the topography of the city and the arrangement of the water mains. If the pressure recorded by each gage be multiplied by the area of its district, and the sum of the products so obtained be divided by the sum of all the areas, the quotient will be an average pressure for the system. By a similar treatment of the elevation of each gage above the river an average elevation of the system may be obtained. For want of a more accurate basis of computation it has been assumed that the consumption of water is uniform throughout the territory supplied. Owing to the location of our pumping plant with reference to the center of the city and district of maximum consumption, whence it appears that the distance from the engines to the point of maximum consumption is about a mean between the distances from the engines to the center of the districts east and west of it, and because the quantities of water consumed east and west of this center of consumption are about equal, this assumption may be shown to be reasonably accurate as far as total or average results are concerned. On this assumption we may say that the product of the average pressure above obtained multiplied by the quantity of water consumed represents the usable work of the system, or that which may be utilized by the consumers, and that the product of the average elevation by the quantity consumed is the work of elevation of the system, or that required to overcome the heights of the territory supplied, from which it follows that the difference obtained by subtracting the sum of these two quantities from the work of the engines represents the work expended in overcoming friction. All observations both of quantity pumped and of pressure are recorded hourly and the work of the engines has been obtained by averaging these records in twelve-hour periods. As the pressure on the system is maintained as nearly constant as practicable the observations for usable work and work of elevation have been averaged by weeks. In the diagrams of Plate I showing the "Work per gallon of oil," no correction to the oil consumed has been made for heating or lighting, but the diagram has

Plate II.


D.P.W.W. 1894.
340,000 Million Foot Pounds
TOTAL WORK
USABLE WORK
FRICTIONAL WORK
WORK OF ELEVATION
TEMPERATURE
June 5 to 12
19 to 26
July 3 to 10
17 to 24
31 to Aug 7
August 14 to 21
28 to Sept 4
September 11 to 18
25 to Oct 2
October 9 to 16
23 to 30
November 6 to 13
20 to 27
December 4 to 11
18 to 25
16 to 23
30 to Feb 6
13 to 20
27 to March 6
March 13 to 20
27 to April 3
April 10 to 17
24 to May
May 1 to 15
22 to 29

been produced by using the total quantity of oil consumed as fuel for all purposes each twenty-four hours.

Before proceeding with the consideration of the causes and conditions affecting the quantity of water consumed attention should be called to a frequent source of error in comparing the reports of various water works. Many cities base the so called *per capita* consumption on the entire population regardless of the fact that a part of that population may be supplied from other sources. The difference between the *per consumer* and the *per inhabitant* consumption daily may be noted for 1893 in the following cases:

Louisville,	per consumer,	104.29	gallons;	per inhabitant,	75.22	gallons.
Cleveland,	"	"	157.91	"	"	"	129.73	"
Detroit,	"	"	158.25	"	"	"	148.00	"

For this reason little information of value can be obtained upon this subject from the reports of those cities where the population is partially supplied from other sources than the water works.

The conditions which appear to affect the consumption of water are in part as follows: The density of the population and its wealth; the age of the works; the moisture in the atmosphere and its precipitation; extremes of heat and cold; temperature of the supply and the quality of the water; the pressure maintained on the system; the condition of the force and distribution mains and the service connections; the pumping mechanism; the restrictions enforced as to the use of water; the number and extent of fires; and last but not least the carelessness of the users.

The effect of density of population is readily appreciated when we reflect that the more thickly populated a district is the less the opportunity for street and lawn sprinkling, which perhaps in a measure accounts for the lower consumption of European cities, and for the large consumption of Detroit, Cleveland and Washington.

The wealth of the population has an important bearing, for the consumption of water where the houses are equipped with bath tubs, closets, wash bowls, etc., is much greater than where the penstock only is furnished. These effects are clearly brought out by the following statistics obtained from the meter department of the Detroit Water Works for 1894:

In Tenements—Single penstock for all, 5 families—27 persons, averaged daily for year, 8¼ gallons per capita.

In Dwellings—Single penstock for each, 6 families—13 persons, averaged daily for year, 19 gallons per capita.

In Flats—Steam heated and with all modern conveniences, 16 families—50 persons averaged daily for year, 39¼ gallons per capita.

In Flats—Steam heated and with all modern conveniences, 16 families—35 persons averaged daily for year, 49 gallons per capita.

In Residences—All conveniences—Mean of several families, averaged daily for year, 50 gallons per capita.

The data for tenements, dwellings and flats were obtained from the meter records in cases where the water was paid for by the landlord and hence the tenant would not have been likely to restrict himself in its use, so it seems fair to assume that these figures represent the reasonable legitimate consumption.

The following matter bearing on the above conditions is abstracted from Baumeister's "Cleaning and Sewerage of Cities:"

"In Berlin in 1887 and 1888 the sewage pumped from a thickly settled but poor district averaged 21.1 gallons per capita daily; in districts with larger street surface and a somewhat higher class of residents, 26.4; in manufacturing districts, 37 gallons; and in most fashionable districts 44.9 gallons. The average consumption of all districts was a little over 26 gallons. The city water works supply 16.9 gallons daily to each person, and private sources add some 13.2 gallons more, making a total supply of about 30 gallons. The difference between the supply and effluent probably measures the quantity used in sprinkling, cleaning, etc., where the water soaks into the ground."

Comparing these figures with those of Detroit we have:

	Berlin.	Detroit.
Poor districts	21.1 gallons.	8½ to 19 gallons.
Middle class	26.4 "	19 " 39 "
Wealthiest	44.9 "	39 " 50 "
Average per capita for entire city	30 "	148 "

In manufacturing, the consumption of Detroit, which amounts to 19¼ gallons per capita daily for all business purposes, appears to be greater than that of Berlin, but falls far short of accounting for the 118 gallons difference in the total consumption.

As to the effect of the age of the works it is noted that the consumption in newly established works is less than that in older ones because the inhabitants having been accustomed to do without modern conveniences are slow to adopt them, even when every opportunity is offered.

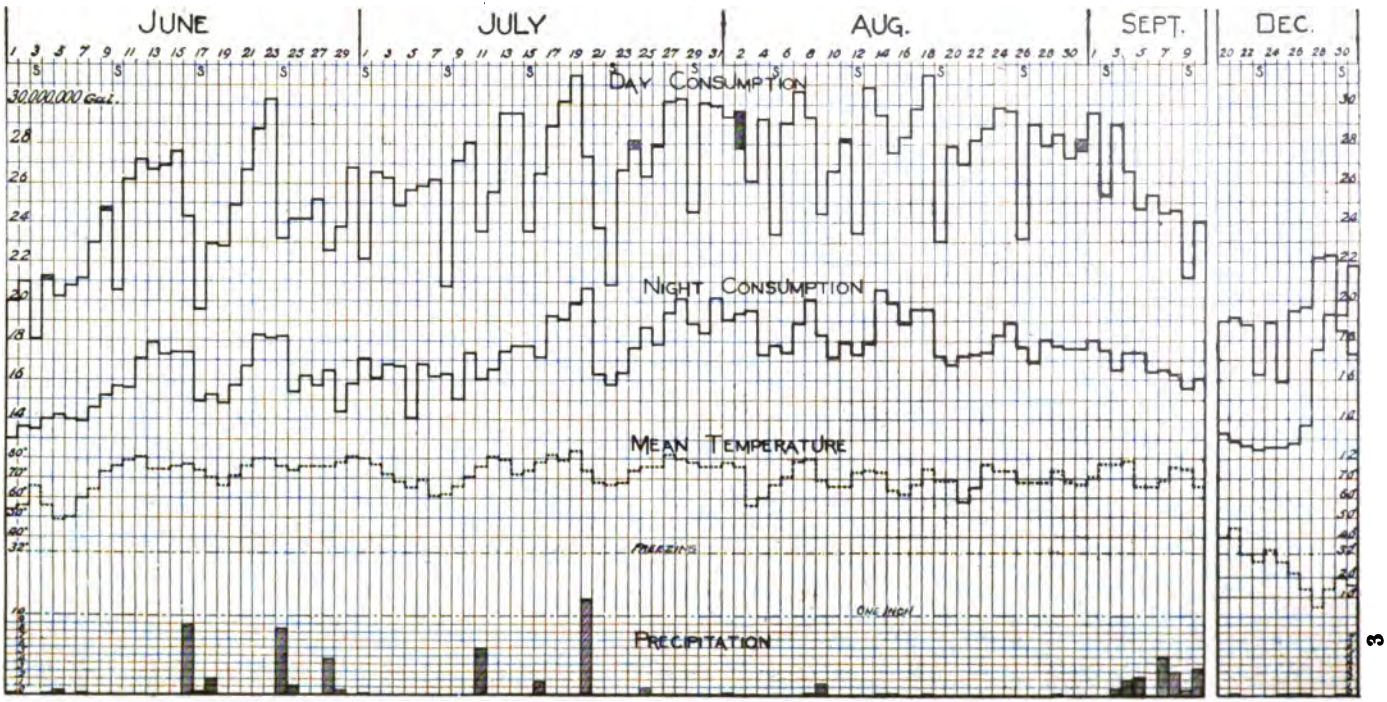
The effect of moisture in the atmosphere is noticeable in the lower consumption of seacoast cities, as Boston, Providence, New York, Brooklyn and Baltimore, when compared with Cincinnati, Philadelphia, Detroit and Washington, in the former of which the consumption ranges from 60 to 100 gallons, while in the latter from 100 to 160 gallons per capita daily. The precipitation naturally has its effect in hot weather, especially in the more openly settled districts where lawn sprinkling is resorted to. Its effect in Detroit may be seen in Plate III, which shows the daily and the nightly consumptions, the mean temperature and the total precipitation for the months of June, July, August, and a part of September, 1894. The effect is very noticeable on June 16, July 10 and 20, August 9, and September 3 to 9, in all of which the changes of temperature were slight. The difference in consumption between Thursday, July 19, and Saturday, July 21, due almost entirely to the storm of the 20th, and resulting fall of temperature, was nearly eleven million gallons, which probably measures very fairly the quantity of water consumed at that time for lawn and street sprinkling and for cooling purposes.

At times of extreme cold people allow the water to run from their fixtures at night, as well as during the day, to prevent

freezing. This is done to such an extent that the maximum daily consumption in Detroit has been in the winter. During the recent cold weather (February, 1895), the quantity pumped amounted to over 60,000,000 gallons in a single day, of which over 29,500,000 gallons was pumped between 7 p. m. and 7 a. m., while in December the consumption daily was only about 32,000,000 gallons for most of the month. The sudden fall of temperature immediately after Christmas produced an increase in the daily consumption of nearly 10,000,000 gallons within three days, as shown at the right in Plate III.

In periods of extreme heat much water will be used for cooling purposes. As explained above from Plate III it appears that about July 21 one-fifth of all the water pumped was being thus consumed. In some cases the hourly consumption is increased to more than one hundred per cent above the average for spring and fall by hot weather usage. Even in Providence, where over seventy-two per cent of all consumers are metered, the July consumption has been forty per cent greater than that of November. From a study of Plate I, in which the average daily water pumped and the mean weekly temperature are shown near the bottom of the diagram, it is seen that variations of temperature between the freezing point and about 55 degrees above zero, Fahrenheit, produce very little effect on the consumption, and from Plate II, in which the ordinates to the line of work of elevation are proportional to the water consumed, and where the precipitation is represented by the cross-hatched areas at the bottom of the plate, it is also seen that the latter has no very decided effect below the higher named temperature.

The temperature of the supply has some effect in hot weather for if the water has become warmed consumers will be inclined to let it run with the expectation that it will become cooler. As has often been observed water flowing in pipes as large as street mains is very slow to take on the temperature of the surrounding soil so that even if it has become considerably heated by passing over shallows or standing in a reservoir it will probably reach the consumers at very near the temperature at which



DETROIT WATER WORKS

CONSUMPTION. TEMPERATURE

1894

Plate III.

3

it passed through the pumps, and in such cases the hope of obtaining cooler water must be doomed to disappointment, but the waste goes on.

The quality of the water may affect the quantity consumed for the reason that more uses will be found for a pure than for an impure supply.

The pressure maintained affects the consumption by increasing the leakage and waste as the discharge through an orifice is a function of the pressure varying as its square root.

The condition of the distribution system as regards leaking joints and leaking taps may have a very decided effect upon the consumption. In Detroit the facts that along several of the lines of pipe water is flowing, that all service connections for years were made by driving a tapered brass plug into a parallel sided hole in the pipe, and that sometimes the caulkers appear to have forgotten to drive the lead in the joints, probably help to account for the excessive consumption at all seasons.

Similar negligence in making and caring for the various service attachments will produce similarly undesirable results. Boston in five years reported 280,227 inspections of which 59,878 or over twenty-one per cent revealed defective service attachments. Of defective fixtures ball cocks gave the most trouble, there being 22.011 cases reported or nearly 37 per cent; sink and bowl faucets come next with 16,749 cases, or about 28 per cent; water closets caused 7,137 reports or about 12 per cent; the remaining 23 per cent being miscellaneous.

Detroit reported 269,521 inspections including second inspections in five years, and from these 16,602 cases of leaks in service attachments were discovered. Philadelphia, in 1893, reported night consumptions recorded between midnight and six in the morning amounting to a total of 366,798,729 gallons, which was accounted for as follows:

Urinals, water closets and accompanying fixtures	228,523,680	gallons or about	62%
Establishments running at night	78,472,080	" " "	30%
Establishments metered	30,695,040		
Hydrants and faucets	19,184,400	" " "	5%
Service pipe, abandoned pipe, etc.	9,923,529	" " "	3%

That the pumping mechanism can affect the true consumption is out of the question; but that it does affect the recorded consumption is equally certain. The so called slip of pumps is usually an indeterminate quantity and the difference in various forms of mechanism is noticeable. As nearly all pumping works register their consumption by piston displacement the effect of a difference of slip may be important. Moreover the maximum and minimum capacities of the engines have an effect, for oftentimes, with the older styles especially, it is necessary at times of minimum consumption to waste water back into the well to prevent the machinery from stopping. It was found that on the introduction of the new Reynolds' Corliss engine at Detroit nearly three-quarters of a million gallons each night appeared saved from the quantity recorded by the old engines.

The restrictions enforced as to the use of water will very materially affect the consumption. If, for instance, the fixtures are repeatedly inspected, if meters are applied generally, if the use of water for certain purposes is restricted to certain hours the result will be a very apparent reduction.

The quantity of water used for fire extinguishing purposes appears often to be greatly overestimated. While a large fire may make an appreciable difference in the quantity of water used in a single day its effect will hardly be noticeable in a large system on a weekly report. During the months of June, July and August, the past year, occurred the largest number of fires in Detroit, and some of the largest individual fires so that the fire consumptions during these months were maxima for the year. From records furnished by the fire department giving the size of hose, size of nozzle, length of line and pressure at engine, and the time run, the amount of water so used has been computed and the quantities are: For June, 785,255 gallons; for July, 1,222,935 gallons; and for August, 3,213,205 gallons. When it is reflected that the daily consumption of Detroit ranges from thirty to sixty million gallons the comparative insignificance of the fire consumption may be at once appreciated. In Plate III the quantities used for this purpose have

been platted as cross-hatched areas near the line of day consumption wherever the amount was sufficiently large to show on the scale of the diagram. The largest quantity is seen to be on August 2, at which time two fires were raging, calling for the services of thirteen engines and consuming about two million gallons of water.

The extent of water consumption due to carelessness is only to be guessed at, although the city of Boston reported in 1888 that in 28,909 inspections 4,794 cases of defective fixtures were found of which 2,062 were cases of willful and negligent waste.

The effect of manufacturing is somewhat problematic. Of course the consumption of a manufacturing city will be greater than that of a rural city, but whether the increase of manufacturing in what has previously been a manufacturing city, in the same proportion as the increase of population, unless the manufacturing develops along lines using especially large quantities of water, will affect the per capita consumption is not as certain. The argument has been used that if a certain series of manufacturing establishments are necessary to a certain number of inhabitants, a similar series of manufacturing establishments will be required for an equal additional number of inhabitants; and hence increase of manufacturing should not increase consumption. This view is apparently borne out by the record of Detroit where in 1876 with 20,102 families supplied the average per family assessment was $10.23 for all purposes, and in 1884 with a population of 29,422 families the per family assessment was $10.21, while the per consumer consumption had increased from 115 to 155 gallons although the same system and rate of assessing had been maintained. As it is presumable that each new manufacturing establishment was assessed in harmony with the preexisting ones it leaves the increase to be accounted for elsewhere.

We may now form an equation for water consumption under its various heads. To this end let:

Q = total per consumer consumption.

D = necessary per consumer domestic consumption.

M=necessary per consumer manufacturing consumption.

F=necessary per consumer fire consumption.

S=per consumer consumption due to lawn and street sprinkling.

L=constant per consumer waste due to leakage.

P=per consumer waste at pumps and error of register.

C=per consumer waste due to cold weather.

H=per consumer waste due to hot weather.

W=per consumer waste due to carelessness.

The average daily equation for the year would then be:

(1) D+M+F+S+L+P+C+H+W=Q; in which the first four terms represent necessary and legitimate consumption, and the remaining five terms of the first member useless consumption, or waste. By choosing the time of observation in spring or fall, with proper regard for temperature, we may eliminate the consumption due to lawn sprinkling, S, the waste due to cold weather, C, and that due to hot weather, H, and thereby materially simplify the equation. As the fire consumption has been shown to be practically insignificant we may drop the term F and the equation becomes:

(2) D+M+L+P+W=Q; the first two terms only representing necessary consumption.

Applying this equation to Detroit we find the following conditions:

First as to D, the necessary domestic consumption, we assume the population of the city to be divided into four classes, as shown in a previous table according to their consumptions:

(a) In tenements using daily 8½ gallons per capita.

(b) In dwellings using daily 19 gallons per capita.

(c) In flats and residences using daily 40 gallons per capita.

(d) In residences using daily 50 gallons per capita.

The average family assessment for the past year has been, for unmetered water, deducting from the total number of families supplied 500 for those metered, about $7.00 (actually $6.98), and from the charges for unmetered water, the assessments for

the several classes would be about $4.00, $5.00, $15.00 and $18.00. During 1894 a reduction of rates was made upon families in addition to the first taking water from a single penstock, from $5.00 to $3.00, and it was estimated that this change would reduce the income $10,812.00 or would affect 5,406 families. From the conditions of the reduction, for every such family there must be not more than one other family in the same house which must pay $5.00 per year. The maximum number of families possible in class *a* would then be 10,812, or about 21 per cent, and on this estimate the average assessment of the class would be as above, $4.00. At the same time the assessment for laundry tubs was abated and it was estimated that 2,613 families were affected. This must be a very fair measure of those in class *d*, whose percentage would therefore be about $5\frac{1}{3}$ per cent.

A further change in rates affecting water closets in addition to the first was estimated to affect 4,200 closets. This reduction would be mainly in class *d* although a part of class *c* might be affected. The evidence of this estimate is simply corroborative of the assumption in the case preceding, as to account for these 4,200 closets we have only to assume that all the 2,613 families of class *d* had one closet affected and that about 60 per cent of them had second closets affected which is not an improbable assumption. As these three estimates were made by the several assessors from a careful study of the assessments of each district, they appear entitled to reasonable confidence. From these several conditions, assuming the percentages of the entire number of families supplied and unmetered in the several classes *a*, *b*, *c*, and *d* to be represented by w, x, y and z respectively, we have the following equations:

Since the total number of families is 100 per cent, $w+x+y+z=100$; since the average assessment per family is $7.00, $4w+5x+15y+18z=700$, and from the estimates on classes *a* and *d* as above, $w=21$ and $z=5\frac{1}{3}$. Substituting these values and solving for x and y we obtain $x=63\frac{1}{3}$ and $y=10\frac{1}{3}$.

For the value of D, the average necessary daily domestic consumption per capita, we then have:

$\{(21\times8\frac{1}{2})+(63\frac{1}{3}\times19)+(10\frac{1}{3}\times40)+(5\frac{1}{3}\times50)\}\div 100 = 20.62$ gals. nearly.

The only assumption which may be criticised is that for determining the class *a* in which we used the maximum possible value for the coefficient. If in relation to this we assume that for every family in class *a* paying $5.00 per annum there are four instead of one paying $3.00, which assumption appears to be certainly above the true condition, as Detroit has very few such tenements as are rated in this class, the average assessment for class *a* becomes $3.40 and the percentage about 14. With these values we find D=21.25 nearly, which value we will use in our equation.

Secondly as to the value of M:

The difference between the week day consumption and that of Sunday in periods of minimum usage is about 4,000,000 gallons, or an average of about $15\frac{1}{2}$ gallons per capita, which must be accounted for by those business uses that are not in effect on the sabbath, but in the meter department we have a more accurate basis of computation. During the past four years the bulk of the manufacturing and business consumers have been metered and during 1894 practically all have been, as well as schools, police stations, fire engine houses and public buildings. The metered consumption on the basis of the entire number of consumers has been daily for 1891, 1892, 1893 and 1894 respectively, 20 gallons, 19 gallons, 24 gallons and $19\frac{1}{4}$ gallons per capita. The $19\frac{1}{4}$ gallons per capita for 1894 includes about 500 private families.

Thirdly regarding the value of Q:

During the months of November and December, 1894, excluding the last week of the latter month, the average daily consumption of this city was about 32,000,000 gallons or about 125 gallons per capita. Of this 4,800,000 gallons, or 19 gallons per consumer, were metered and represents the value of M at this time.

Now substituting these values in equation 2 we have:

(3) L+P+W=84.75 gallons, whence it appears that in times of minimum consumption for every gallon used two gallons are lost. If we allow for the slip of the pumps ten per cent of the entire quantity pumped, which is greater than any slip that has come to the writer's knowledge, and is far greater than we are prepared to believe to be the real case, it only accounts for 12½ gallons and still leaves 72¼ for waste and leakage.

As an evidence of the correctness of these deductions we find that a constant waste of 84¾ gallons per capita daily would amount to about 900,000 gallons per hour, which is just about the minimum record of our works during the past two years and is frequently approached between one and four o'clock in the morning.

Now, in further corroboration of our conclusions, a comparison with the city of Providence is interesting. That city had in 1890 a population of 122,043 and Detroit had 205,669. In 1893 the populations were estimated at about 160,000 and 250,000 respectively. In the former city they now have over 72 per cent of all consumers metered, those unmetered being only families with a single penstock. The population is reported to be nearly all supplied from the water works and basing the *per capita* consumption on the entire population it was, for 1893, 57 gallons daily. For the month of November the average Sunday consumption was less than the average week day consumption (figured on Tuesdays, Wednesdays. Thursdays and Fridays) by about 32 per cent of the whole. As this difference must be a pretty fair measure of the business consumption—in Detroit the same difference was about 80 per cent of the total daily metered consumption, but as New England is more strict in sabbath observance than is Michigan the percentage there would probably be higher—it indicates that the manufacturing and business consumption is not less than one-half of the domestic and public consumption in Providence. If we assume the same condition to be a proper one

Fig. 1.

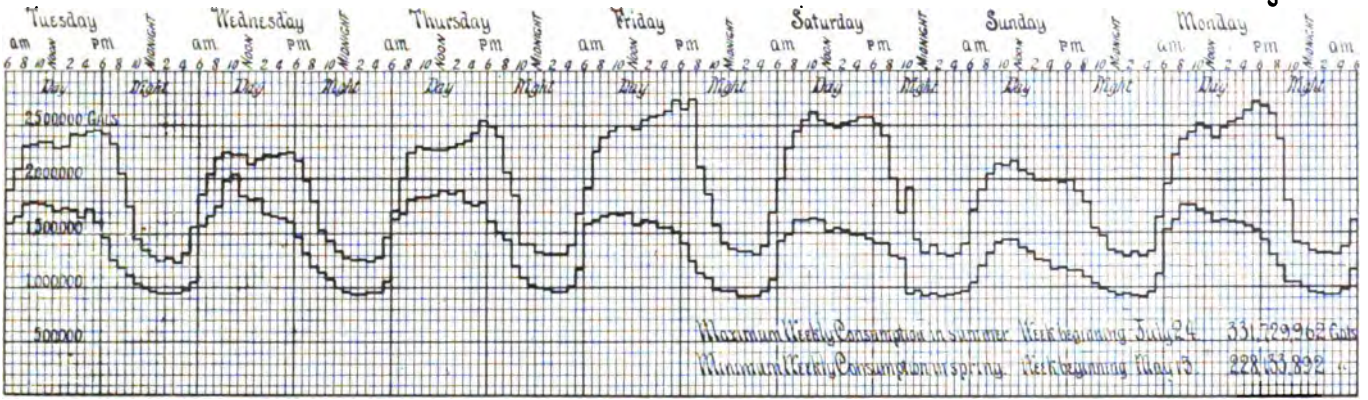


Fig 2.

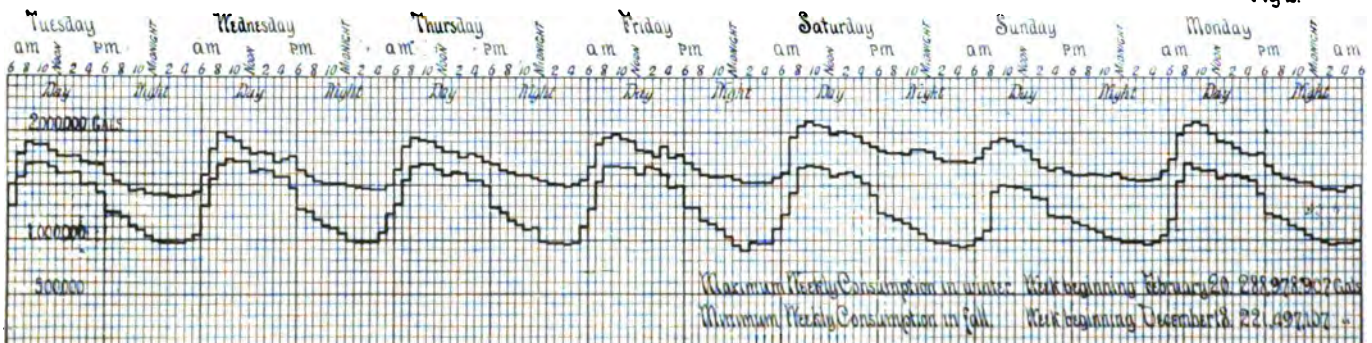


Plate IV.

Detroit Water Works. Weekly Consumption by Hours 1894

for Detroit where we know the business consumption to be 19 gallons per capita, it gives us for other purposes about 38 gallons, leaving for waste about 68 gallons or using the Sunday difference in Detroit as in Providence, the waste would be about 78 gallons per capita which is not far from the 83¾ gallons previously obtained and this without considering any part of the 57 gallons of Providence as wasted.

For the other terms of our general equation S, H and C, the first two may in a general way be determined by comparing the consumption of the hot months with that of spring or fall and C may be determined by similarly comparing the consumption of the cold months. A reference to Plate IV will emphasize these comparisons.

From the preceding deductions, with an abundant allowance for lawn and street sprinkling, it is apparent that over 50 per cent of the water pumped in our city is wasted, producing no good results and what is the case here must be the case in a greater or less degree elsewhere. The conditions for legitimate useful consumption are probably more favorable in Detroit than in almost any other city in America. The population is spread over a large area; excluding about 30,000 it is a population that appreciates the benefits of a plentiful supply of water as is to be noted from the fixtures in the dwellings of even ordinary mechanics; the winters are severe and the summers often hot and dry; and last but not least, it is almost impossible to obtain water from any other source than the water works. If, then, in a city like this, 50 to 60 gallons daily covers the necessary and reasonable *per capita* consumption may we not expect that Philadelphia's 160 gallons, Cleveland's 158 gallons, Chicago's 150 gallons, Cincinnati's 124 gallons, even Boston's 104 gallons is to a large extent wasted. From the Philadelphia report for 1892 I find that in a certain district a per capita consumption of 523 gallons was found which by stopping leaks and repairing fixtures was reduced to 63 gallons. Another examination in the same report gives for a district a total daily per capita consumption of 252 gallons of which leaks

in mains accounted for 9 gallons, waste for 157 gallons and the usage was only 95 gallons. In the report of the same city for 1893, a consumption of 264 gallons per capita is divided into 140 gallons wasted and 124 gallons used.

Boston measuring a night consupmtion between one and four in the morning, and including 80 per cent of her consumers in the examination, reports the hourly night consumption as two-thirds of the day consumption.

Although this enormous waste exists in American cities the deduction of a manufacturing consumption of 15 to 20 gallons per capita proves pretty conclusively that we will not be likely to reduce our consumption to European figures.

The causes of waste being known the methods for reducing it are to be considered. There are two standpoints from which waste is to be treated. The one is the case where the supply is unlimited and the reasons for restricting its consumption are purely financial ones. The other is where the supply is not unlimited and the demand is approaching the limit. In the first instance if the consumer is willing to pay his share of the cost of pumping and of the interest on the plant he should be allowed as much water as he desires, but in the latter case the supply must not be wasted and it is proper to prescribe its legitimate uses and the quantities to be allowed for each. The solution of the problem so far as the premises of the consumer are concerned demands only in the former case the application of the meter, but under the latter circumstances inspection and stringent regulations are required in addition.

In the study of waste and its location a most useful instrument was recently patented in England and has already been considerably used in this country. It is known as the Deacon Waste Detection Meter. By the application of this device to the mains supplying a district the quantity of water consumed at any time may be determined and whenever this appears to be excessive by trying the meter successively on different lines the point of waste can be located. This instrument has already been used largely in Boston and Philadelphia with very satis-

factory results. Its essential parts are a tapering tube and a disc which closes the smaller end, but is attached to a stem and counter weighted so that it may be moved toward the larger end of the tube. This device is placed in the main so that the water flows through the tube, entering at the small end. Its operation depends upon the principle that the distances of the disc below the top of the tube are very nearly proportional to the quantities of water passing by it in its different positions. A pencil on the stem and a moving plate operated by clock work comprise the registering apparatus and we have a meter which is probably quite as accurate as the recording mechanism of the pumps.

The first point to be looked after in the prevention of waste is the distribution system itself. The sources of waste here are the joints of the pipe, the stuffing boxes of the gates and the hydrants. For the gates and hydrants the remedy lies in a frequent examination. The subject of tight joints is one of more importance, the securing of which requires great precautions. The system of laying pipe usually adopted by contractors, of caulking two or more pieces together on the bank and then lowering them into the ditch is one that can hardly be approved. Although it is theoretically possible to so suspend three pipes from two derricks as to allow of no strain upon the joints, yet this condition is not necessarily fulfilled in the ditch when the pipe reaches its final position. Personally the writer believes in laying each pipe on a block just back of the bell and pouring the joint with the pipe in the position where it is expected to remain. This requires a little more care in back filling than where the block is not used, but at the same time it does away with the bell hole digger on small pipe. The amount of lead necessary in a joint is, I think, frequently over estimated. There is rarely if ever any reason on water mains to use more than two inches of lead and the less yarn it seems to me the better. The yarn being fibrous at first prevents the water from getting through the joint, but after it is saturated its efficiency is decreased. For this reason a heavily yarned

joint will not show leakage on a first test, but oftentimes after a day or two will be found leaking. In these days of electrolysis of water pipes and the possibility of the joints especially being affected, the subject of another jointing material than lead is being considered. Portland cement has been used both on water and gas lines, made into a thick putty and rammed into the joints and is reported to have given good satisfaction. In St. Johns, New Brunswick, a line of iron pipe laid in 1857 in which wooden wedges were used for making the joints was dug up in 1892 and the caulking reported in excellent condition; and rubber has been successfuly used in Europe under pressures, it is reported, as high as sixty pounds. To be assured of the tightness of the joints, whatever the jointing material, the line must be tested in the open ditch to as high a pressure as it is likely to be called upon to withstand, and this test should be continued twenty-four hours if possible, and the longer the better. I have known lines that were tight for the first six or eight hours to leak at the end of twenty-four. The line should be carefully inspected, particular attention being paid to the bottom of the joints while under pressure. A leak on the bottom is an evidence of bad caulking, for a caulker who understands his business will drive the bottom of the joint first so that as the top is caulked the spigot is forced down upon the lead below, thus rendering the bottom doubly tight. It is well to have the caulkers put an individual mark upon their work so that bad joints may be located. The caulker is the one man on the work that should not be hurried but should be allowed to do a first class job on every joint. I have not found any way of telling a first class job, however, except to get water in the pipe and put on the pressure. In inspecting lines under pressure any evidence of the water on the inside getting on the outside is an evidence of a leak. The contractor may call it a "sweat" and declare that it does not amount to anything, but he should be made to stop it just the same for these "sweats" rarely improve with age. In inspecting lines laid by contractors where joints were made on the bank,

I have found thirty out of thirty-five consecutive joints leaking. On the other hand where the pipe is laid on blocks and all joints made in the trench four leaking joints in a man's day's work are as many as are usually found and often not more than one or two at 150 pounds pressure. The comparative cost of the two methods for the same class of work is about the same.

The next source of waste to be looked after is the service connections. The so called corporation cocks should be of brass and screwed into the main. Care should be taken that all cocks used in connection with the works have the nut and washer at the bottom of the plug. The cock with the riveted plug should not be tolerated. If service cocks with the stop and waste are used, care must be taken that they are set right end to, so that the waste may not take place from the main when they are turned off. On the whole it is safer to use the plain cock for the service and let the owner take care of the waste on his own premises when he wishes to avoid freezing.

The interior fixtures should be first class. Cup joints in lead pipes are not to be relied upon. The tank closet is usually considered the least wasteful as well as the most efficient from a sanitary point of view. Urinals are a lasting source of waste. But probably the most unreliable fixture presides over the kitchen sink. Spring faucets are a partial safeguard, but nothing is like the meter for taking care of this part of the waste. It is even related that in some places the moral effect of the meter is such that merely the case with the working parts removed and an inspector to look at it occasionally will materially reduce consumption. In a hospital in Detroit in 1894, by metering, the consumption was reduced from 625 gallons per capita daily in October to 447 gallons in December.

As said before where the supply is adequate the way to best handle the subject of waste beyond the pipe lines is to put a meter on the service at the property line and let the consumer pay for what he gets at a uniform rate. If, however, the supply is deficient then the meter should be placed and all consumption above an established allowance be charged for at a

rate sufficiently high to deter any from useless waste. Inspection alone it has been proven time and again has no lasting effect upon careless and willful waste.

A means of reducing consumption and also expenses of operation that may sometimes be found available is by the reduction of pressure. For domestic purposes where houses are not more than three stories in height thirty pounds is an abundant pressure to carry and it may sometimes pay to divide a system into an upper and a lower service, or probably into three, and thereby reduce the pressure in some portions. The subject of waste at the engines due to their minimum capacity being greater than the minimum demand upon them is one that should be carefully considered for it is a very easy matter to waste the supply for 10,000 people at the engine house in a very short time. Such was the case with the engines of the Detroit water works until quite recently. These were vertical, compound, condensing, beam and fly wheel engines having of course two water ends, and could not be run down to the minimum demands without stopping on the centers so that it was often necessary to open a waste gate and pump back into the well. Our present engineer hit upon the plan of connecting the two upper ends of the pump cylinders by means of a by-pass through a ten inch valve and in addition attached to each one a six-inch gate opening to the air. By this device, opening all three gates, it is possible to change an engine from full to half capacity in less than two minutes, and to increase it as rapidly. The device is in successful operation on two twenty-four million gallon engines.

To reduce consumption in cases where the supply of potable water is limited it has been proposed for our sea coast cities to use ocean water for fire extinguishing, street cleaning and the like. Detroit, Cleveland and Milwaukee have adopted a separate auxiliary fire supply system, not for the purpose of curtailing the consumption from the water works, but to afford a more effective means of fighting fires. The system is to lay, in streets at right angles to the water front, lines of pipe fitted with

connections at the lower end for attaching a fire boat which is equipped with powerful pumps and can be readily moved from place to place as occasion may require. Detroit has nine such lines varying in length from seven hundred to four thousand feet. By this means it is possible to concentrate heavy, direct pressure streams at any point along the line. Although thus far no tests have been made for an accurate determination it seems to be admitted that the streams so generated are more effective than those of the same size and at the same pressure supplied by steamers. This may be accounted for by the supposition that the water in passing through the pipe line has an opportunity to so arrange its particles as to issue from the nozzle in a more solid stream than when it has just passed through an engine.

In closing, to glance for a moment at the financial phases of the subject of waste, in the Detroit system the frictional losses range from less than 8 per cent at times of minimum usage to over 30 per cent at the maximum, with an average value of 17 per cent of the total head pumped against by the engines. If there were no waste the frictional losses would never amount to more than 12 per cent and would average less than 8 per cent. Referring to Plates I and II it will be readily seen how important this item is, and then add to it the reduction of the work of elevation by over 50 per cent, and of the usable work similarly, and the effect upon the fuel bill will be at once self evident.

Discussion.

THE PRESIDENT: Are there any remarks on this paper?

PROF. GREENE: I don't think I can add anything to what has been said. Mr. Williams has covered the subject so thoroughly, and has presented the remedy which seems most feasible to me, and all I can say is that I desire to thank him most heartily for the favor he has shown us in preparing so elaborate a discussion on so valuable matter.

MR. WILLIAMS: I would like to thank Prof. Greene for his

kind remarks, but some of the ideas I have advanced here may be contrary to those that some of you who have had experience may hold. If anyone has anything that controverts them, I would like to hear it, and I don't wish anyone to feel that he may hurt my feelings by pitching into this paper. I want a free discussion, and if anyone has arguments against, or for, my conclusions, I want them as much as you do.

COL. MUENCHER: I think Mr. Williams deserves the thanks of this society for this paper. I have read volumes on the subject of water waste, and have never seen the matter presented in so striking a manner. The tables show the relative value of the sources of waste in a manner I have never seen illustrated before. It is in investigations of this sort, that the greatest information can now be obtained on engineering questions. Our theories on engineering are pretty well settled, but the practical part is still very much behind, and it is in just such investigations as this, that the best results for the profession can be found.

I think Mr. Williams deserves our thanks for the labor he has evidently expended.

PROF. GREENE: What does "consumer" mean; what relation does it bear to the number of taps?

MR. WILLIAMS: On a rough estimate, about five persons per tap. The number of persons supplied, per tap, is larger this year than last, because the hard times have compelled people to double up, but by referring to the census, we have been able to determine it, and the number this year was very nearly five. It may be interesting to state another fact about our system. The city is supplied through two 42-inch force mains about two miles in length as shown on the map opposite page 32 by the heavy lines at the right. Our investigations proved that the loss of head from the engines to the gages at Concord and Mt. Elliott Avenues indicated on the map by double circles amounted to two-thirds of the entire average frictional loss of the system as a whole.

MR. APPLETON: To what do you attribute the loss of friction from the near by stations?

MR. WILLIAMS: The results of our examinations have demonstrated conclusively that the friction is mainly due to the 42 in. mains being too small. We want more of them.

MR. SEARS: I feel like congratulating the society on the manner in which this gentleman has presented this subject. I do know a little about this matter of waste, and I will tell you of something that occurred at my own home. One cold night not long ago, I thought of keeping up the fire a little longer. in order to guard against freezing. My wife said, "There is no use wasting wood, leave the tap open."

The house should be so constructed as to remove the necessity of this means, and that item of waste should be eliminated. One important feature is the laying of pipes. No care should be omitted in the laying of pipes.

I am very particular with my lawn, and to take good care of it, I wet it in the evening. I see hundreds throwing water in the heat of the day. That poisons the atmosphere, and hurts the grass. Most people don't know that.

COL. MUENCHER: No, nature never sprinkles the grass, unless she puts a cloud over the sun first.

MR. ROGERS: Are the water mains laid by contract?

MR. WILLIAMS: No, sir; by the city.

MR. HILLYER: Would you regulate the location of water pipes in buildings, by city ordinance?

MR. WILLIAMS: We make certain requirements as to the depth at which service connections shall be made, but we cannot go inside of the man's building. The building inspector could, but it depends very much upon the provisions of the local charter. I think though that generally the water departments should be allowed to go in and specify as to the manner in which the water should be used.

COL. MUENCHER: Don't you think it would be a good policy for the public to take charge of the laying of service pipes,

from the street mains into the house, and not allow private parties to do that?

MR. WILLIAMS: In the ideal system, I should have the city control everything in the street and have the meter at the property line, and then let the consumer put in what he wishes.

QUESTION: Wouldn't it greatly lessen the waste at night, to put in a stop cock, where the service enters the building, so that the property owner could shut that off at night, in the house.

MR. WILLIAMS: That is usually done, but no one would think of shutting it. You couldn't persuade a man to do that, I think. If he is going to waste water, that is making it all the easier for him to do it; making it all the more difficult to get him not to waste it.

COL. MUENCHER: Those things don't always work either. In my house we have a stop that is supposed to shut off the water at night, and we try to use it, but the pipes freeze up just the same, so we have abandoned the use of it entirely, and we let the water run. There is no choice. It freezes below the stop.

PROF. GREENE: The stop is not low enough then?

COL. MUENCHER: The cold up there penetrates pretty deep.

PROF. GREENE: Isn't the meter the best remedy?

MR. WILLIAMS: The meter takes care of the waste, but if you sell the water so cheap that one doesn't care whether he wastes it or not, he doesn't take any pains to save.

The point is, a good many would find it easier to turn on the water in the kitchen than turn it off in the cellar, and you must supplement the meter by a frequent inspection, and even then it seems the net effect would be short of what is desired.

I think the time is coming when all of our great cities will have to construct separate systems. Let the supply for domestic use have a system apart from the water used for fire purposes, lawn sprinkling, washing out sewers and everything of that kind.

MASONRY CONSTRUCTION OF THE NEW LOCK AT SAULT STE. MARIE, MICH.

J. L. CALLARD.

Before entering upon a description of the masonry construction of the new lock (known as the 800-foot lock), a brief historical sketch of the St. Mary's Falls canal may not be uninteresting:

St. Mary's river, the only waterway between Lake Superior and Lake Huron, is about 75 miles long, the rapids of St. Mary are 15 miles from Lake Superior. The fall in the river from Lake Superior to the rapids is 1-10 of a foot, the fall at the rapids is 18 feet, and from the foot of the rapids to the level of Lake Huron the fall is 2.3 feet. The rapids form an impassable barrier to communication by water between Lake Superior and the lower lakes.

Governor Mason, in 1837, called the attention of the State Legislature to the advisability of constructing a canal at the rapids of Sault Ste. Marie. The Legislature acted favorably upon his recommendation, and an act was passed authorizing a survey, plans, etc., to be made, $25,000 was appropriated by the act for that purpose. The survey was made by John Almy during the summer of 1837, and in his report he recommended that a canal and two locks be built of the following dimensions:

Width of canal, 75 feet; depth, 10 feet; length of locks, 100 feet; width, 32 feet; depth, 10 feet. Estimated cost, $112,544. In 1838 Governor Mason again called the attention of the Legislature to the subject, and that body appropriated an additional $25,000 to be applied to its construction. On the 7th of September, 1838, a contract was entered into with Smith & Driggs, of Buffalo, New York, to construct the canal. In May, 1839, the contractors commenced work by filling up a govern-

ment mill race, located upon the military reservation. The post commander at the head of his command forcibly ejected them from the grounds, and the work was abandoned.

In 1840, the subject was brought up in the Senate of the United States where it met with great opposition. Among those who opposed it was Henry Clay, who in a speech referred to it as "a work beyond the remotest settlement in the United States, if not in the moon." A survey, however, was ordered, and was made by Captain Canfield of the United States topographical engineers. In 1852, a grant of 750,000 acres of public land was made to the State of Michigan. The grant was accepted by the State, and a private company agreed to build the canal and locks from the proceeds of the land.

Work on the locks and canal was begun on June 4, 1853, and completed June 11, 1855. The canal was 5,400 feet long, 100 feet wide, and 12 feet deep at the mean stage of water. The locks, two in number, were at the eastern extremity of the canal; each lock was 350 feet long, 70 feet wide, with a depth of 11½ feet over the miter sills, and a lift of 9 feet. The cut stone for the lock walls was limestone, Marblehead, Ohio, and Malden, Ontario; the backing was limestone from Drummond Island, St. Mary's river and Potsdam sandstone excavated from the site of the canal. The cost of the canal and locks was $999,802.

In 1869, the tonnage passed through the locks was 500,000 tons, and the vessels had increased so much in size that the largest ones had to be locked through singly, and could not be laden to their full capacity without drawing too much water to be passed through the locks. Colonel Cram, corps of engineers, then in charge of the district, in his annual report to the chief of engineers for 1869, strongly urged deepening the canal to 16 feet and the locks to 17 feet over the miter sills.

In July, 1870, congress appropriated $140,000 for that purpose. Work was now begun on a project which contemplated the enlarging of the canal, and building a new lock south of and parallel to the then existing lock.

The new lock was to be 515 feet long, between gates, and 80 feet wide narrowing to 60 feet at the gates, with a lift of 18 feet and a depth of 17 feet over the miter sills.

The face stone for the lock walls was limestone from Marblehead and Kelley Island, Ohio. The backing was limestone from Drummond Island.

This lock was opened to commerce September 1, 1881. On June 9, 1881, the State of Michigan transferred the old locks to the United States.

Lieut. Col. Weitzel in his special report of June 14, 1882, urged the commencement without delay of operations looking toward the immediate construction of a new lock. In succeeding reports his recommendation was repeated. In Col. O. M. Poe's annual report to the chief of engineers for 1884, he recommended making the proposed lock 21 feet deep, and increasing the depth of the canal to correspond. By the river and harbor act of August 5, 1886, an appropriation of $250,000 was made "for continuing improvement by a new lock and approaches." Col. O. M. Poe thereupon submitted a general project to the chief of engineers based upon a navigation 20 feet in depth, this included a new lock 800 feet long between gates, 100 feet wide throughout, with 21 feet of water over the miter sills, located upon the site of the old State locks.

Work on the coffer dam for the 800 feet lock was begun in May, 1887, and completed the following season. The cost of this work was for dredging by the hour, $59,044.50; for 2,635,847 feet B. M. of timber, $37,428.92; for framing, building, and fitting the cribs, $14,982.22; for 662,410 pounds iron drift bolts, $4,651.23; for 64,424 cubic yards of clay, $36,077.56; total, $152,184.43. The coffer dam inclosed an area of about 1,500 feet long and 300 feet wide.

Excavating the site for the lock was begun in April, 1889, and completed in August, 1891. The cost of the excavation was for 130,085 cubic yards of earth, $55,936.55; for 106,602 cubic yards of rock, $141,780.66; total, $197,717.21.

The cut stone for the walls of the 800 feet lock is limestone from Kelley Island, Ohio. It is a corniferous limestone, rich in fossils, of the Upper Helderberg group. The bottom of the quarries is in the flinty course that also constitutes the bottom of the Marblehead quarry section. This is followed by nine feet of stone, the "bottom rock" of the quarrymen, quarried to be burned into lime; six feet of building stone, nine feet of "cap rock," used for flux and pier stone surmounted by four feet of extra cap rock so called, which is a blue, highly fossiliferous but very thin bedded limestone. The last section is probably the lowest portion of the Sandusky section of the Upper Helderberg. There is about fifteen feet of rock below the bottom of the quarries above the water level.

The stones for the lock were taken from the "block stone" or "south" quarry. In this quarry the "building stone" ledge varied in thickness from six feet at the west end to twelve feet at the east end.

The quarrying was done with Wardwell channelers, and Ingersoll-Sergeant gadders and drills.

The four channeling machines were of the double-gang type of special pattern, being designed to cut channels six feet ten inches apart, this being the length of a stone in the rough from which a stone six feet long could be cut. These channelers are locomotive, cut while moving in either direction, reverse without stopping, automatic feed, feeding forward on the track half an inch at every stroke, each side striking about 150 blows per minute, width of cut one and one-half inches. The depth of the cut is increased one-half inch each time the channeler passes over it. The channel cuts are well flooded with water while the channelers are in operation.

The five gadders were used to drill horizontal holes, diameter of hole, one and one-quarter inches.

Four drills "C" size were used for top drilling, diameter of hole one and one-half inches.

Four drills "A" size were used for trimming, drilling subdivisions, etc., when plug and feather was to be used, diameter of hole one inch.

What is known as the Knox system of blasting was employed in quarrying the stone.

Channels were cut parallel to the face of the quarry, and to the depth of the bed. Lines of horizontal holes were next drilled along the face with the gadders, the lowest of the lines was located at the bottom of the quarry, the location of the other lines depended upon the thickness of the stone required, the holes were drilled about three feet apart and about one foot less in depth than the distance from the quarry face to the first channel cut. Then lines of vertical holes were drilled between the quarry face and the channel cut, the distance apart of these lines depended upon the areas of the beds of the stone required, the holes were drilled about two and one-half feet apart, and about one foot less in depth than the thickness of the ledge.

The holes were next elongated in the direction of the desired line of fracture by means of a reamer.

The bottom line of horizontal holes were then charged with the explosive, a charge consisted of about one-half pound of common black blasting powder, "B" grade. In charging the holes a plug was placed about one foot above the cartridge, thus forming an air chamber. The holes were then fired with a battery the force of the concussion breaking the whole mass of stone from its bed. The vertical holes were next discharged in a similar manner, one line of holes at a time. The remainder of the horizontal holes were discharged as the work demanded.

By this system of blasting immense monoliths can be loosened from their beds. In quarrying the stone for the 800 feet lock, the largest piece measured 90 feet long, 6 feet, 10 inches wide, and 8 feet thick, and weighed about 387 tons.

Each dimension of the stones in the rough was at least four inches greater than the corresponding required dimension of

the finished cut stone. About 26 per cent of the volume of the stones in the rough was lost in cutting.

The stones were transported to Sault Ste. Marie, Michigan, in the rough and cut on the government land back of Fort Brady pier.

Four Merriman planers were used to assist in cutting the stone. Each stone after being planed had to be dressed down to exact dimensions and finished by stone cutters. The planers were operated twenty-two and one-half hours per day, and averaged about 600 stones per month.

The stone yard covered an area of about 1,100 feet long and 150 feet wide. The stone were distributed for the cutters by means of a McMyler traveling derrick which traveled on a track extending lengthwise through the center of the yard.

All show faces of cut stone, excepting the tops of the coping stone, were finished with a one-quarter inch chamfer, and a two inch chisel draft, having three bats to the inch, one-sixteenth of an inch deep. The chamfer was omitted from the tops of the coping stone and a "drove finish" substituted for a tooled one. The space between the chisel drafts on the show faces of the stones of the lower eleven courses, excepting coping and recess stones, had a rock face finish, having no depression below the plane of the face, and no projection greater than one inch above it. This space on all other stones had a bush hammer finish.

The stones for the miter walls were cut to three-eighths inch joints throughout; the coping stones were cut to three-eighths inch joints, excepting the bed joints that overlie the backing; the vertical joints of the other stones were cut to three-eighths inch for eighteen inches from the face, and the horizontal joint were cut to three-eighths inch except where overlying the backing.

The faces of the look walls consist of 23 courses of cut stone. Courses 2 to 22 inclusive are each 2 feet thick; course 1, which extends from the east end of the look to a point 4½ feet west of the toe of the recess for the intermediate gate where there is a

drop in the floor of 1½ feet, is 1½ feet thick; course 23, the coping course, is also 1½ feet thick.

The walls are each 1,100 feet long. From the east end for 282 feet the walls are 45 feet high, and from that point westward they are 43½ feet high. The walls of the lock chamber are 20 feet wide at the base and retain this width for 10 feet, when by five 2 feet offsets 5 feet apart they are narrowed to 10 feet in width. The ends of the walls are 36 feet wide from base to top.

There were laid in the walls 14,278 pieces of cut stone, of which number about 10,000 were of the same size, namely, 6 feet long, 3 feet wide, and 2 feet thick. This being the size of the ordinary headers and stretchers.

All the cut stone were dimension stone and in cutting the maximum variation allowed on the show faces from the given dimensions was 1-16 of an inch.

All excess in width of stretchers or length of headers was paid for as backing.

The cut stones were all lifted by means of lewis. There were two types used, the round-pin lewis and key, and the rectangular-keyed lewis of three parts, the latter for the heavy stones.

The largest stones in the lock walls when cut contained 105.26 cubic feet and weighed 8.28 tons, the mean volume of the total number of pieces cut was 35.44 cubic feet.

The cut stone weighed 157.23 pounds per cubic foot, determined by obtaining the mean specific gravity of 70 samples. From tests made at the Watertown arsenal, its ultimate crushing strength is 12,177 pounds per square inch, this is the average of nine test specimens of 3 inch cubes. The specimens were tool dressed, and the compressed surfaces were faced with plaster of Paris.

The drawings of the cut stone masonry consist of three complete sets. Set No. 1 consists of 13 sheets each 24 inches wide and 72 inches long, made to the scale of 1-16 of an inch to the foot. In general each of these sheets contains the drawings of two complete courses of cut stone, giving the shape, location,

and pattern number of each stone. There are also two sheets of the same size, giving general and detailed drawings of the lock floor. A progress sheet of this same size and scale was made at the end of each month to accompany the monthly report to Col. O. M. Poe.

Set No. 2 consists of 31 sheets, each 12 inches wide and 40 inches long, made to the scale of $\frac{1}{8}$ of an inch to the foot. Sheets numbered 1 to 23, inclusive, of this set contains the details of the east and west end of each course of cut stone of the north wall, that is, of the gate recesses, gear passages, etc., which consists largely of stones of special design, while in the lock chamber proper each course consists of alternate headers and stretchers of the same shape and size. The remaining sheets of this set are detailed sheets of special parts of the lock walls, this set was intended for use on the work.

Set No. 3 consists of 16 sheets each 26 inches wide and 40 inches long, made to the scale of $\frac{1}{2}$ of an inch to the foot. This set comprises a detailed drawing of each stone having a distinctive pattern number giving all necessary data required for cutting the full sized zinc patterns.

A distinctive pattern number was given to each stone differing either in dimension or finish from its fellows. The pattern numbers were from 1 to 532 inclusive.

A full sized pattern in zinc was cut for each set of stones, whose shape was other than rectangular, 471 such patterns were cut in duplicate, one set for the United States inspector at the stone yard to be applied when inspecting the finished stone, and one set for the contractor for the use of the stone cutters.

After being cut, before shipment from the stone yard to the lock pit, each stone was carefully inspected, as to imperfections in the stone, workmanship, dimensions, wind, etc., by the United States inspector, and those that passed inspection were marked with the proper pattern number and also a running number. By means of these numbers a complete record was kept of each stone, such as volume required, excess if any, date

of inspection, of shipment to the lock pit, and of laying in the lock wall.

The concrete foundations of the lock walls were laid to a line three feet out from the face of the masonry. To assist in laying the first course of cut stone, strips of 3x6 inches white pine were bolted to the concrete with fox-wedged bolts, along the line of the face of the wall. The bolt holes in the templates were elongated at right angles to the face of the masonry so as to admit of their being adjusted for alignment by loosening the nut. The inner edges of the templates were beveled, leaving a vertical face of about $\frac{1}{2}$ inch in width at the top. This face was carefully planed to line. The templates were laid on a bed of Portland cement mortar, and accurately aligned with a transit. After a rain or when aligned long before the stones were laid, it was necessary to re-align them. The curved templates for the gate recesses and miter walls were made from 1 inch boards, two thicknesses of boards being fastened together so as to break joints, and were accurately set by means of ordinates. Certain points, such as the ends of the walls, springing points of the miter walls, etc., were permanently marked with punch marks on the top of iron bolts firmly set in the concrete.

All measurements were made with a standardized steel tape, with a tension of 8 pounds applied, and corrected for changes in temperature. Zinc plates were fastened on the wooden templates at certain distances apart, and the points they were intended to locate were accurately marked on them with the point of a knife. For the straight walls of the lock chamber, these plates were placed 99 feet apart, and so located that each 99 foot mark was also the center of a joint. For those parts of the lock walls outside of the chamber they were placed at such points as the heel and toe of each gate, recess, etc. From the joint marks on the zinc plates the intermediate joints for each stone were marked on the inner edge of the templates, both the center and sides of each joint being marked. The points on the zinc plates were transferred to the top of each succeeding

course of masonry with a transit, and the joints for each stone similarly marked.

Water for use on the works was pumped from the Edison Sault Electric Co's Canal by two No. 1, Worthington pumps, through 2-inch pipes laid on either side of the lock-pit. These were tapped at suitable distances for the attachment of hose.

The following constitutes the main part of the plant in and about the lock pit in use on the masonry construction. In all there was about 10,000 feet of tramway, 3-foot gage. A double track extended the whole length of the works provided with the necessary side tracks, crossings and switches. A single track was also laid to the spoil bank along the north bank of the canal. Fifty-six platform cars, of 10 tons capacity each, were used for transporting material into the lock pit. There were also in use about 30 ordinary dump cars, hauling the filling placed behind the lock walls.

A Ledgerwood, double-drum, double-cylinder hoisting engine was located at each end of the lock pit at the head of the incline.

Four stationary steam derricks, of 15 tons capacity each, and operated by a 8½x10 inch double-drum, double-cylinder, Ledgerwood engine, were used for unloading the stone from the barges and scows and loading them on the cars for shipment into the lock pit. They were all of the same size and make, mast 68 feet high, boomed 50 feet long, two stiff-legs, each 66 feet long supported by "A" frames, 34 feet long. Two of them, one at each end of the work, were provided with turntable and steam swinging attachment. The booms of these derricks can make a complete revolution.

Eight traveling derricks, four on each side of the lock pit, were used for laying the stone in place on the lock walls. They were built by the McMyler Manufacturing Co. of Cleveland, Ohio. Four of them were of ten ton capacity each, with the boom (54 feet long) swung at a radius of 33 feet, and was operated by a 12x14 inch double-drum, double-cylinder engine.

The other four were of 5 tons capacity each, and operated by a 9x12 inch engine. These derricks can travel at the rate of 600 feet per minute, can hoist, revolve, and raise or lower the boom when traveling at full speed. They weigh about 45 tons each, are 16-foot gage, using a 95 pound rail. These derricks laid the stone in place on top of the chamber walls of the lock, the top of the walls were ten feet wide and about 43½ feet above the top of the rail. During the winter of '92-3, the trestles were built to the level of the tenth course of masonry, from the upper lock gate miter wall to the west end of the lock, upon which two of the two larger sized derricks were placed, one on either side. This was done to enable the derricks to travel above the miter walls and to lay the backing on the back part of the wide walls.

Eight stiff-legged derricks were used at the east end of the lock during the season of 1893, to lay the backing on the back part of the wide walls, since those parts of the walls could not be reached by the traveling derricks above the 13th course of masonry.

The rock crushing plant consisted of a No. 2 and a No. 5 Gage crusher. The No. 2 proved to be too small and was later exchanged for a No. 4.

A scow 100 feet long and 30 feet wide, provided with a No. 6 sand pump and rotary engine, was used for transporting the sand. The tug that towed the scow furnished the steam for operating the sand pump. A small derrick operated by a rotary engine was used for unloading the sand near the head of the west incline.

A tug was chartered by the season, but all scows were owned by the contractors. The tug was employed in towing and loading sand scow, and towing scows laden with stone from the stone yard at Fort Brady Pier to the places of unloading for shipment into the lock pit. Besides the above enumerated plant there was a large miscellaneous plant such as carts, harnesses, wheelbarrows, etc.

The stone used for the concrete was the Pottsdam sandstone excavated from the lock pit. An inspector was stationed at each crusher to see that none but good hard stones were used, some of the stone being very soft. In general the stones were broken to pass in every way through a ring three inches in diameter. On leaving the crusher, the stones were passed through a revolving wire screen, having openings about $\frac{3}{8}$ of an inch square.

The sand used both for the concrete and the masonry was pumped from the bottom of the river about six miles above the locks, and a short distance from the shore near Point Aux Pins. It was even-grained, sharp, coarse and clean.

The "Milwaukee" brand of natural cement was used both for the concrete and laying backing. The specifications required that "the avearge gross weight per barrel should not be less than 300 pounds. At least 90 per cent of the cement by weight shall pass through a seive with 2,500 meshes to the square inch. The cement shall stand a tensile stress of at least 60 pounds to the square inch when mixed neat and exposed one hour in air and the remainder of the 24 hours in water, and at least 100 pounds to the square inch when mixed neat and exposed one day in air and six in water, and when mixed in proportions by weight of one of cement and one of sand, and exposed for seven days as described above, it shall stand a tensile stress of at least 50 pounds per square inch. A cement will not be accepted that cracks or checks when made into thin cakes, or that, when made into stiff mortar, sets hard enough in less than 30 minutes to bear a weight of one pound on a wire 1-24 of an inch in diameter."

There were two brands of Portland cement used, "Hemmoor," a German cement, and "Empire," an American cement, much the greater part used was of the "Hemmoor" brand. The specifications required that "no barrel shall weigh less than 375 pounds gross, and the average gross weight per barrel shall not be less than 400 pounds. At least 95 per cent of the cement by weight shall pass through a seive with 2,500

meshes to the square inch. The cement shall stand a tensile stress of at least 400 pounds to the square inch when mixed neat and exposed one day in air and six in water, and when mixed in proportions by weight of one part cement to three of sand and exposed in the same manner it shall stand a tensile stress of at least 125 pounds per square inch. A cement that cracks or checks when made into thin cakes or that begins to set in less than 30 minutes would not be accepted."

Before acceptance every third barrel of cement received was tested for tensile strength, every thirteenth for fineness, every tenth for time of setting and pat test, and at least one barrel from each cargo is tested for specific gravity. Besides these regular tests, innumerable special tests are being made.

The work of construction was begun on June 29, 1891, when the first batch of concrete was laid.

All shattered and disintegrated rock was removed from the area over which the concrete was to be laid for the foundations of the lock walls, and levels taken 3 feet apart for the purpose of computing the volume of concrete laid.

The concrete was of one part "Milwaukee" natural cement, 1½ parts sands, and four parts broken stone. A batch consisted of 5.25 cubic feet of cement, 7.88 cubic feet of sand and 21 cubic feet of stone. In mixing, the sand was spread evenly over the bottom of the mixing board, and the cement spread evenly on top of it. The cement and sand were first thoroughly mixed dry and then into a rather stiff mortar. The mortar was spread evenly over the mixing board and the stones, after being washed and allowed some time to drain, were spread over it. The stones and mortar were then mixed by four shovelers, two on each side of the board, first casting out and then casting in. When carefully done, three castings were sufficient to insure a good mixing, but this largely depended upon the skill of the shovelers. Each shovel full should be turned completely over and spread.

In general, a gang of concrete mixers consisted of 13 men. Each gang had a set of three mixing boards, placed side by

side on the completed concrete. Each mixing board was about 12 feet long and 6 feet wide, with ropes attached to its forward end for the purpose of pulling it ahead. In the operation of mixing, two men deposited the sand and the cement on each of the three mixing boards in rotation, these were followed by two other men who mixed the mortar and spread it in readiness for the stone, the stones were then dumped from a cart upon the mortar and after being evenly spread were thoroughly mixed by four shovelers. These again were followed by four other shovelers who cast the concrete into place, in layers of about 8 inches thick, when it was properly rammed by a man with a hard wood rammer, weighing about 30 pounds, each successive layer being stepped back to avoid vertical joints. In this manner, concrete was laid to grade in sections about 12 feet long and the full width of the foundation, the mixing boards being pulled ahead after the completion of each section. Just before placing the first layer of concrete on a section, the rock was washed off and while wet a thin coating of soft mortar was applied and spread with a broom to insure the filling of all cracks in the rock and also a good bond between it and the concrete.

An inspector was stationed with each gang to see that the proper proportion of the component materials were used, and the work of mixing and placing properly done.

The concrete foundations are laid to a line 3 feet out from the face of the masonry wall. The average thickness of the concrete foundation is about 3 feet.

A series of tests are being made to determine the transverse strength, etc., of concrete. These tests are being made with concrete bars 10 inches square and 4 feet long between the knife edges, in which the proportions of the component materials are varied, and also in which different kinds of materials are used.

The total amount of concrete laid in the foundations of the lock walls, walls of the pump well, etc., was 10,522 cubic yards.

Total barrels of cement used for concrete, 16,221, an average of 1,352 barrels of cement per cubic yard of concrete.

The first stone was laid September 2, 1891. Laying cut stone was stopped for the season of 1891 on October 15; for the season of 1892, it was resumed on May 5, and stopped on October 27; for the season of 1893, it was resumed on April 29, and stopped on November 10.

A gang for laying cut stone consisted of a mason foreman, two masons, two helpers, one mortar mixer, one man to fill joints, the use of a traveling derrick and an engineer to operate it. One fireman fired for two derricks.

The cut stone were laid with mortar composed of one part Portland cement, and one part sand.

An inspector was stationed with each gang laying cut stone, whose duty it was to see that each stone was set true as to line and elevation; that the mortar was properly gaged; that each stone was thoroughly cleaned and moistened just before being laid, and the joints properly filled. He also kept the daily record of the number of barrels of cement used, and the number of pieces of cut stone laid, the number of the course in which each stone was laid, together with its pattern and running numbers. About every third course of cut stone was laid with a level, and the faces of the walls frequently tested for line. The largest number of pieces of cut stone laid by one gang on any one day was 62, the largest number of pieces laid by one gang in any one month (25 working days) was 822.

The total cut stone laid was 18,741.04 cubic yards. Total number of pieces of cut stone laid, 14,278. Total number of barrels of cement used for laying cut stone, 4,525; an average of 0.242 barrels per cubic yard of cut stone, or 0.292 barrels per cubic yard of cut stone masonry.

The backing stone for the 800 feet lock is limestone from Drummond Island, St. Mary's river. A quarry was opened about midway between the two quarries from which the backing stone for the locks of 1855 and 1881 was taken. The stone covered with glacial drift, varying in thickness from one to five

or six feet. The quarry face is about 700 feet long and 30 feet high.

The stone of the upper ledges is light colored yellowish white, earthy fracture, laminated structure, breaking into angular blocks when exposed to the frost. But very little of the upper 12 feet was good for backing. Most of the ledges were too thin, and all were full of joints. The stone of the middle ledges, about 10 feet thick, is dark grey, having a crystalline structure. The stone of the bottom ledges is about the same color, etc., as the top ledges. The middle and bottom ledges vary from 8 to 40 inches in thickness and were all good stone, being easily broken into rectangular blocks, some of which weighed over 8 tons. The stone is very compact, weighing 170 pounds to the cubic feet.

In laying the backing it was required that stone should break all vertical joints at least 9 inches with the stones of the course below, and, whenever possible, all stones should break joints, at least 9 inches with all stones adjacent to them. In general, stones were required to have an area of bed of at least 5 square feet and to be at least 8 inches thick.

Payment was made only for the volume actually occupied by the stone. The method followed for computing the volume of backing stone laid for the monthly estimates and also for the final estimate, was to compute the total volume of masonry laid, and from that volume deduct the volume of cut stone laid and the mortar used.

Before being laid in place all stones were washed clean. The spaces in the vertical joints due to irregularities in the shape of the stone were filled with spalls laid in mortar, the narrow joints were filled with mortar only. No leveling pieces were allowed to be used, except when breaking over a change in level on the top of the next lower course. The use of grout was prohibited.

The mortar used for laying the backing stone was of one part of "Milwaukee" natural cement and one part sand. One barrel of cement and 3.8 cubic feet of sand, when mixed with

sufficient mortar to form a rather stiff mortar measured 6 cubic feet.

An inspector was stationed with each gang of masons laying backing, to see that the mortar was properly gaged, and the stone properly laid as to bond and joints, and the joints carefully filled. He also kept a daily record of the cement used.

The total backing stone laid was 48,276.04 cubic yards, of which the United States furnished 3,762.79 cubic yards. This consisted of old cut stone taken from the walls of the lock of 1855. There were used for laying backing stone 58,410 barrels of cement; an average of 1.21 barrels per cubic yard of backing stone.

The total masonry laid was 80,876.61 cubic yards. There were used for laying the masonry 62,935 barrels of cement; an average of 0.778 barrels per cubic yard of masonry. Of the total masonry laid 59.7 per cent was backing stone, 23.1 per cent is cut stone, and 17.2 per cent was mortar. The cost to the United States of the masonry of the 800 feet lock was for:

Laying 10,522 cubic yards concrete @ $4.50 per cubic yard	$47,349 00
Furnishing 18,741.04 cubic yards of cut stone @ $26 per cubic yard	487,267 04
Laying 18,741.04 cubic yards cut stone @ $2.50 per cubic yard	46,852 60
Furnishing 44,513.25 cubic yards backing stone @ $6 per cubic yard	267,079 50
Laying 48,276.04 cubic yards backing stone @ $2.50 per cubic yard	120,690 10
Furnishing 7,650 bbls. Portland cement @ $3 per bbl	22,950 00
Furnishing 71,755 bbls. of natural cement @ $1.30 per bbl	93,281 50
Total	$1,085,469 74

The anchorages for the 10 leaves of the gate were built into the masonry. These anchorages consist of 10 anchor boxes, 40 anchor castings, 112 saddle castings, and 240 steel eye bars, together with the necessary bolts, etc., having a weight of 542,428 pounds exclusive of the anchor boxes. Cost, $20,477.64.

The pointing was done by the United States. At the time of setting the cut stone, the masons were required to rake out the joints to a depth of about two inches. After the mortar had set, the joints were carefully pointed with mortar, composed of two parts Portland cement and one part fine sand, passed through a number 40 seive and thoroughly washed. The mortar was mixed as dry as it could be well worked. Before filling

with mortar the joints were thoroughly moistened. A caulking iron and mallet was used in filling the joints and a steel beading iron to form and polish the bead.

Perhaps the magnitude and importance of this work can be impressed in no better manner upon the minds of the members of this society than by giving a few statistics from the records of the canal.

The following is the total expense of operating and care of the St. Marys Falls canal from date of opening to June 30, 1894:

1881	$31,207 48	1889	$37,237 48
1882	35,509 70	1890	45,417 66
1883	31,214 93	1891	61,389 74
1884	27,240 45	1892	42,412 12
1885	25,400 95	1893-4	55,213 09
1886	22,138 92		
1887	29,898 72	Total	$475,030 69
1888	30,749 45		

An average of $36,540.82 per year.

This includes the care of about 80 acres of government property and over 2½ miles of timber pier. The great fluctuations from year to year are largely due to repairing and renewing the superstructure of the piers.

The following is a statement of the commerce through St. Marys Falls canal for the year 1874, 1884, 1890, and 1894:

Year.	Number of vessels.	Registered tonnage.	Number of Passengers.	Total freight, net tons.
1874	1,734	1,070,857	2,295	
1884	5,318	2,997,837	54,214	2,874,557
1890	10,140	8,454,835	24,856	9,041,213
1894	13,884	13,110,366	27,236	13,195,860

The following is a like statement for the Suez canal for the years 1873, 1883, and 1893:

Year.	Number of vessels.	Registered tonnage.	Number of passengers.
1873	1,173	1,367,767	68,030
1883	3,307	5,775,861	119,177
1893	3,341	7,659,059	186,495

In comparing the commerce of St. Marys Falls canal with that of the Suez canal it must be borne in mind that the average time the locks of the St. Marys Falls canal are in operation each year is but seven months, while the Suez canal is in operation throughout the whole year.

TITLE BY POSSESSION.

BY JUDGE HOOKER,

Of the Supreme Court of Michigan.

It is the policy of the law to place a limit upon the longevity of human contentions. Hence our statutes of limitation, which justify the general statement, that actions, to enforce the payment of debts and performance of contract obligations, must be brought within six years, and to recover damages for what the law denominates torts, or wrongs, such as trespasses, unlawful conversions, slander, etc., within two years, after the right of action accrues.

The same policy lies at the foundation of titles to land by prescription, which may be as perfect titles as any other, and at common law was said to exist "When a man shows that he and those under whom he claims have immemorially used to enjoy the lands that he claims." Early English statutes made definite the term "immemorial usage," or perhaps more accurately speaking, substituted a fixed and definite period for it, by providing that an uninterrupted enjoyment for sixty years, should confer an absolute and indefeasible title to land.

These acts, were in effect, statutes of limitation, and they have been changed from time to time, in our country, until the requisite periods are now much shorter. In many states, and for a long time, twenty years was the period required for a title by occupancy to mature, and in most places, that probably represents the popular understanding upon the subject today. It may be of interest to my auditors, if I state that in Michigan the period applicable to ordinary cases is fifteen years. When the defendant claims title under a tax deed, it is ten years, and when he holds under deeds given upon judicial sales, such as sales by executors, administrators, guardians, sheriffs and the like, the period is five years.

Exceptions to these statutes exist in favor of minors, and others, which it would be unprofitable to discuss here.

In an old and well settled country, where the land is all reduced to possession and under cultivation, holdings adverse to the true owner for a long period would probably be few, while in a new and sparsely inhabited country, where much land is unoccupied and covered by forest, and possibly owned by persons living at a distance, such holdings may reasonably be expected to be more numerous.

The short period usual in this country where from the nature of things the owner of land would seem to require more protection against unwarranted appropriation, is in striking contrast to that of England, where, as already implied, the necessity for a long period of limitation would seem to be less.

This is an interesting subject for reflection, in connection with the differences in the form and methods of the two governments, but one which there is no occasion to mention further.

The first requisite to a valid title by possession is that the government or State should have parted with its title, for title to lands owned by the State or federal government cannot be acquired by occupancy. Ordinarily this fact is unimportant because most land has been conveyed by the government, and it is mentioned only to emphasize the fact that whatever rights may exist by reason of occupancy as against private persons, no title is ever perfect and complete unless based upon a grant from the government, and no period of occupancy prior to such grant would furnish any support to a claim of title by possession, against the grantee of the government.

It has been said that the period of limitation is to be computed from the time that the right of action accrued to the plaintiff or some person through whom he claims. It is therefore obvious that it is not every kind of possession that will answer for a foundation to a possessory title. It must be one that is wrongful and upon which an action may be brought for the possession. Hence occupancy under a lease or other posses-

sion of the owner, recognizing the owner's right, by acts such as the payment of rent is insufficient. And although the term for which the lease was given has expired, a continued possession will not ordinarily be considered an adverse holding, the law in such cases assuming a continuation of the relation of landlord and tenant, and that the possession is held in recognition of the landlord's title.

Again occupancy by one tenant in common was formerly considered a holding for the cotenant and in recognition of his title, and while this rule has been relaxed in some places, an occupancy to divest a cotenant's title must be such as to clearly show that it was in denial of his rights, for no title can be acquired by an occupancy which the law does not presume, or the facts show, to be in denial of the right of the true owner.

The possession must be in opposition to the rights of the plaintiff, i. e., adverse, and it is this requirement that gives the name to the kind of occupancy which will suffice, viz., "adverse possession."

Adverse possession comprises several essential elements. These are laid down plainly enough and are as follows: Such possession must be

Actual,
Continued,
Visible,
Notorious and distinct,
Hostile.

In a country where the land has long been reduced to actual possession there would usually be little difficulty in determining whether an occupancy was such as to conform to the popular understanding of these terms, rendering it easy to ascertain whether it was such an occupancy that it could be properly said to amount to possession. But in this as in many other matters the conditions of land and of society in this country have been, and still are, radically different from those

of the mother country, and they have affected the law of this subject, which has been modified with a view to adapting it to altered conditions.

Possession must be actual.

Ordinarily this might seem easily determinable, and so it would be but for the difference in situation, character, and condition of real property, and the uses to which it is put. For instance, the case of a farm of a few acres, all under fence and cultivation, where the family lives in the dwelling thereon, would leave little chance for a dispute over the question of actual possession.

On the other hand, a woods pasture remote from the dwelling, or a marsh where grass is cut annually—especially if not under fence—might raise a more difficult question to decide.

The law therefore recognizes the propriety of a rule, that the requisite actual possession shall be that which conforms to the character of the property, and the uses to which it is adapted, and which therefore, can be reasonably expected, by one who is interested in enquiring whether it is occupied or not.

So it is possible to acquire the right of flowage by the continuous overflow of land by means of a dam, where it is exclusive of the use by the owner, and in denial of his right, for the requisite period, and this is true though drouths, and the exigencies of business, or the breaking of the dam might at times relieve the land, or some of it, from the flowage.

Cattle cannot at all times occupy all parts of a pasture, especially as they are wont to herd together, and they may be driven home nights and taken elsewhere during inclement and wintry weather. Meadows may be actually occupied in the strict sense, only when grass is cut, which in the absence of all other circumstances might not amount to a continued possession, if it did to more than a temporary trespass, but leaving hay stacked upon the premises would tend to strengthen the claim of adverse possession. So leaving wood corded in a wood lot, piling brush, and burning it, and other acts too numerous to

mention, are significant facts, if they tend to show that such use is being made of premises as the nature of the land permits.

Possession must be continued.

But little need be said upon this branch of the subject. Once actual possession is taken, it may ripen into a title, if it is not interrupted, but if at any time during the requisite period an interval occurs in such actual possession it is fatal.

A possession is not broken by a sale and transfer, where the grantee takes possession when the grantor goes out. In such case it is continuous, and the grantor's possession inures to the benefit of the grantee. There are cases where the use of property is intermittent, so to speak, and here questions are likely to arise over the question of continuity. This subject has already been alluded to in the discussion of the character of the possession required.

The possession must be visible, distinct, and notorious.

No clandestine or secret or concealed occupancy will answer, but such as it is, must be open to the observation of all. It must be distinct, i. e., of a character inconsistent with a recognition of another title. It must be such as to fairly imply the assertion of a right to the premises, to the exclusion of all others.

And it must be such as to *involve plain evidences of dominion over* the land. It must be of a character to make it notorious.

A claim of possession which is not so manifested as to be known and understood by others in the vicinity could hardly be said to be visible, distinct and notorious.

The possession must be hostile, and by this is meant that it must be in the assertion of a right, inconsistent with ownership by the plaintiff, one which does not recognize, but from its character, disputes his right, an entry and occupancy without asking his permission or implying his consent, one that is in disregard of him and his title, and one which, from the acts committed, implies the assertion of dominion as contradistinguished from an intention to commit a mere trespass. A man may hunt or fish every day upon the land of his neighbor without intending to claim the land, or he may do it in such a way

(as by his erection of permanent structures for the purpose, leaving his property there, asserting his ownership to others, denying the right of the true owner, etc.), as to clearly indicate an adverse possession rather than a trespass.

The rules that I have stated are probably as well and uniformly settled as any in the law, yet I must make the discouraging admission, that no class of cases will furnish a better opportunity for charging the proverbial uncertainty of the law, than those involving the claim of title by adverse possession. This will be easily understood, if not already divined, when I call attention to the fact that there is no infallible test to apply to facts, which may be asserted to establish such a title. When the jury, or for that matter the judge, comes to apply these rules to the facts established, they or he must determine whether those facts do show an occupancy that is actual, continued, visible, notorious, distinct and hostile. Here is the call for the exercise of judgment, here the opportunity for the effect of prejudice, favor, bias, and the various other insidious, though not necessarily reprehensible influences, which affect human action, and to which much of the supposed uncertainty of the law may be ascribed. Aside from such influences there may be much difficulty in a case, by reason of its proximity to the theoretical dead line, which separates a possession which is sufficient, from one which is not sufficient to constitute title by adverse possession. For instance, all can see that a close question might arise over possession of a wood pasture, or a swamp where only wild grass grows. If under fence that fact would go far, but if not, and the cattle of the entire community roamed at will, together with those of the plaintiff, the grazing of his cattle alone would furnish little or no evidence of possession. If, however, the plaintiff's own cattle were herded there to the exclusion of others upon the notorious claim that he owned the premises, that fact would be of importance upon the question, and quite significant; how significant would be a matter for judgment in the particular case.

While some particular facts might be said to be conclusive

of the question, in most cases they are not. A fact which standing alone might strongly tend to prove or disprove the question, may become of little force, under the light shed upon it by other circumstances. The result must usually depend upon the combination of facts, and their force is determined by the exercise of the judgment of the tribunal.

It is unnecessary to multiply illustrations of this difficulty, or to go at length into a citation and rehearsal of cases and facts which have been held to constitute or not to constitute adverse possession. Had I the time it would only beget confusion in your minds. The only practicable thing for any of us to do, is to understand the rules and make as just and reasonable applications of them as possible.

I have no doubt that many, perhaps all of my hearers have in mind cases where they are or have been in doubt whether the title was complete or not, and possibly cases where it may be thought that erroneous decisions have been made by courts or juries in the premises. If so, permit me to add that in all probability most of these are close cases, about which minds may well differ, either as to the facts proved, or their potency in establishing title. Some of them may have been miscarriages of justice, which it is idle to deny are not infrequent in these cases.

Depriving one who has a clear paper title of his lands, upon no better grounds than an unlawful occupancy is too much like defeating an honest debt on the ground that the creditor has been unduly lenient, to entitle the recipient of the benefits arising from such a transaction to very much commendation. The doctrine is well settled, however, and doubtless is productive of good; indeed it is indispensible from a public standpoint whether it can be said to conduce to common honesty or not.

There is a class of cases where possession of land plays an important part in the acquisition of title, though the statute of limitations is not involved, and this in the face of the statute of frauds, which declares that interests in land greater than leases for a single year, shall not be conveyed, otherwise than

by instruments in writing. I refer to cases where adjoining proprietors have settled and fixed a doubtful or disputed boundary. Theoretically at least, all parcels of land which have been surveyed, have fixed boundaries. Wherever the government surveyors have surveyed lines, and set stakes, the lots have had actual boundaries, howsoever much they may have become involved in doubt, by the real or imaginary loss, decay or removal of landmarks.

It is not difficult to suppose a case where doubts which have long existed, may be removed by indisputable evidence of the original monuments, long after the owners have adjusted their differences. While such adjustment might not change the boundaries of the governmental subdivision, it might conclude the parties. Thus it will be seen that the owner of the northeast quarter of a section might by such adjustment of a boundary, become vested with an absolute title to be a part of the land that, when it was surveyed, was within the actual bounds of the northwest quarter. They have agreed that the respective quarter sections extend to the boundary settled upon. Where the parties have agreed upon such boundary and acquiesced in an occupancy in accordance with it, the law fixes no particular time within which the owner shall be barred of his right of action. This has been said to be based upon the doctrine of estoppel, which cannot be considered in this paper. It should be added, however, that a possession sufficiently long and under circumstances calculated to imply acquiescence is necessary.

To the lawyer this subject opens several interesting questions which it would be impracticable to discuss here, were they of importance to you, which for the most part they are not.

One, however, suggests itself as worthy of mention, and that is the effect of such settlement and acquiescence upon other parcels and proprietors. It must be manifest that no agreement that can be made, or acquiescence in occupancy, by adjoining proprietors, ought to be permitted to affect the boundaries of

owners of other lands, so that while a court of justice may properly say to the owner of an eighty acre lot, *your* line is here, a surveyor could not properly say that the line of that *eighty acre lot* was in that place, thereby establishing new and false lines and monuments to the embarrassment if not injury of others. The lines and monuments of governmental subdivisions should be immovable and unalterable, while as between parties and their privies, the boundaries of their possessions may be affected and, as a matter of fact, changed by acquiescence, the effect being the same as though it was done by a formal deed of the land by its true and proper description. If it were true that by the agreement and acquiescence mentioned, the line between governmental subdivisions should be held to be changed, and surveyors should erect or change goverment stakes and monuments to conform to such agreements and user, land titles and boundaries would soon be in a state of confusion.

As I gather from members of your profession, surveyors as a rule are impressed with the fact that they are searchers after established lines, boundaries and monuments, that their mission is not to create but to find. They search for the foot prints of others, and you must all appreciate the danger that there may be of the very search, obscuring the trail, which time, and the elements have done so much to efface. Hence the caution with which the law accepts a new monument.

In the trial of cases involving surveys, I have felt the embarrassment due to a want of experimental familiarity with the surveying of land, and have been impressed with the inability of courts and juries to appreciate and understand the full significance and value of evidence, upon which professional witnesses place great reliance. It is not surprising that the latter sometimes think that their opinions about where a line is, should be received as evidence without stating the evidences upon which such opinions are based. Doubtless such opinions are frequently nearer correct than the conclusions of the courts. But the fact remains that it is the province of the

court and jury to decide the questions, which the engineer makes plain by the evidences which he finds by means of his survey.

But I am perhaps digressing from my subject, and I will conclude by saying that I have endeavored to give you the general outlines of an important subject, one which is not especially abstruse, except as it becomes so in its application.

My observation is that in such cases it is easy to bury general principles under a mass of cases, which while they illustrate the rules, beget confusion from apparent and sometimes real inconsistency.

From the nature of things this paper cannot be exhaustive of the subject. It is hoped, however, that it may afford some light where questions of possession arise.

It was voted that the thanks of the society be extended to Judge Hooker for his kindness in preparing the paper for the society.

PROF. GREENE: I would like to ask your honor if there is any different construction of the law with regard to infringement on the property of adjacent owners—private individuals or municipalities—where lots encroach on the streets; whether a private individual can gain title by adverse possession against the public in the highway.

JUDGE HOOKER: My understanding of that is this: The general principle is that the highways cannot be obtained by private persons, by adverse possession. I think, however, that it has been held otherwise in this State.

MR. HODGMAN: That is a question which is coming up in most of the villages and cities. I think it has been decided that long occupation of the streets determines the lot lines, forms new boundaries of lots.

JUDGE HOOKER: I do not recall any such decisions, but it would be quite likely that you might find decisions which the occupation of the street was such that it would be strong evi-

dence of where the boundary was. And from analogy, in regard to the rule for fences, which many times furnish evidence of this kind, and yet as suggested, that may be limited by reason of the subject discussed in the paper, viz., acquiescense or agreement about boundaries or in the tendency to build temporary fences, leaving room to build more permanent ones.

MR. HODGMAN: The decision I referred to, judge, is in the case of Van den Brooks vs. Correon, 48 Mich. 283. The effect of that decision of course is where they have not become established, by possession, to change lot lines.

JUDGE HOOKER: That perhaps would be your construction, but I doubt very much whether the court, upon reviewing the question you raise, would hold that long acquiescence would change a boundary. It might, under the application of the rule of adverse possession, hold that the proprietor's land would extend to the boundary, but as to affecting other lots throughout the block, I doubt it.

Of course, where blocks have an overplus of land, the owners throughout the block divide up the surplus, but these controversies seldom get further than the locality where they arose, and are usually adjusted.

I should doubt, without being compelled to submit from the reading of the case itself, whether it could be said, that as a matter of boundary, occupation would change it, in the sense I am speaking of. It might change it as between the municipality and the individual. Suppose a line of lots, six or eight in number. Lot No. 1 encroaches, and we will say for the sake of the argument, succeeds in acquiring title by possession. Now if you set the line there, you must bring the lines of the rest out to it, which perhaps had never been there, and no title acquired.

The same point arose in the paper where I was discussing the subject of boundaries by acquiescence.

MR. HODGMAN: The point I wish to make clear is this: The supreme court of our State, in the case of Van den Brooks

vs. Correon, says: "When streets have been opened and long acquiesced in, in supposed conformity to the plat, they should be accepted as fixed monuments in locating lots or blocks contiguous thereto or fronting thereon." What I want to get at is how far does that decision reach? Suppose that a street, like one that I know of, has been long occupied and acquiesced in, in a different place from that in which it was originally surveyed and platted, does that fact change the interior lines of lots in the blocks fronting on that street in cases where those lines have not been settled by rights of possession?

JUDGE HOOKER: As between the individual and municipality that might be considered evidence of where the line was, but I think not beyond this.

In that same connection, I may say that the encroachment also of the block, the location of the boundary fence might be the strongest kind of evidence as to where that block was, and it might be such that the surveyor and the court would accept it as the true line. If subsequently it transpires that evidence is found as to where that line was, and it should appear that this boundary was wrong, I have no doubt but that the courts then would determine the true boundary to be the one. They might be compelled to say that the municipality and owners and others had acquired rights by occupancy, etc., but I think you see the danger of treating as a true boundary that which is not. That is, in the sense that boundary is used, in the government surveys, or in the surveys of city plats. And yet, in a great many instances it conduces to harmony and peace and perhaps I may add, it is quite probable that these fences are the best evidence, where other is lacking.

MR. HODGMAN: We surveyors are the first ones called upon to consider that question and we want to understand it.

COL. MUENSCHER: That question was up before the society yesterday, and we were on the verge of deciding as to whether to reverse the decision of the court below or not.

The question was whether an error made by a county sur-

veyor in making his first survey, on the interior of a section, was binding on subsequent parties; supposing for instance a surveyor makes an error in subdividing a section. Of course the government corners are immovable, but suppose the county surveyor makes an error in subdividing the section, can another surveyor go on afterwards and correct that error?

JUDGE HOOKER: I do not understand that any surveyor has any authority to bind anybody. The parties may bind themselves by consenting that his survey shall be their line, and acquiescing in it, as by any other agreement, but the mere fact of a man's making a survey does not determine anything finally. It is in evidence. The parties must go to the courts for their final rights, and then the conclusions of the surveyors, and the circumstances upon which they are based, are used to determine the rights.

COL. MUENSCHER: The mere fact of a man's being county surveyor would not destroy the rights of a property owner?

JUDGE HOOKER: I have always understood that the office of county surveyor did not carry with it any presumption of accuracy beyond that which is implied from the ability of the man to become a sufficiently respectable citizen to secure the office. Presumably unless he were a man of ability and character, he would not get the office. But his survey would gain no especial strength by the fact that he was county surveyor.

COL. MUENSCHER: And his putting the survey on record, would not give it any sacredness that it would not have otherwise? It would still be open to question?

MR. HODGMAN: There has been a decision of a circuit court to this effect: The first surveys in subdivision of a section, made by a county surveyor, made in accordance with the laws of the United States and of the State, and monuments planted by him at that time, are conclusive in the same sense and in the same way that the monuments and surveys of the government are; that when he has once made a survey and recorded it, neither he nor any one else can change it.

JUDGE HOOKER: The evidence afforded by the record of the

survey of a county surveyor, or any other surveyor, at an early date, when the land marks are all standing, would be entitled to considerable weight, at a later time when these monuments are gone.

I do not know, of course, and would not like to express any opinion about the holdings of any courts, unless all the facts and evidence could be before me. Of course when the court has a case before it, it decides on that case, and it may be that from the evidence in the case you mention, the court would be justified in saying that the survey was conclusive in that case.

MR. HODGMAN: The point I wished to call attention to was the broad general principle laid down by the court.

JUDGE HOOKER: Many times a proposition may be laid down as an abstract proposition to the ordinary hearer, but all courts in treating the subject afterwards, would read it in the light of what was before the court, and perhaps hold that it was not the intention to lay down a proposition which would be iron clad.

MR. MARHOFF: I would like to ask a question. Can village authorities compel the removal of an encroachment upon a street that was there, when the village was incorporated?

It is in the shape of a fence on the section line. The fence stands in the road. The road is on a section line, and stood there when the village was incorporated. Can the village authorities compel the removal of the fence?

JUDGE HOOKER: Your question implies that it was an encroachment. Usually villages are given the control of streets. Of course where they are organized under special charters, it is difficult to tell what their rights and powers are unless you have the charter before you. But I think as a general rule the care and supervision of streets is conveyed to village officers. The township officers no longer have authority where the village officers have, and I know of no reason why the village officers, when they come to take the supervision of these matters, would not take them with all the rights which existed before, in other words, that a man would not be so

fortunate as to gain title to land in a highway, simply because the public had seen fit to change from a township to a village government in that locality.

Of course those matters depend largely upon the powers conferred by the legislature, for the village has no power except as the legislature gives it.

MR. MARHOFF: Suppose this fence had stood twenty years previous to the incorporation?

JUDGE HOOKER: That is another question.

MR. MARHOFF: Could anyone remove it?

JUDGE HOOKER: Of course that hinges on the question that was asked before. Whether it was possible to gain title to land in the highway by adverse possession, or occupancy, and in the next place, whether the power had been conferred at any time.

MR. MARHOFF: If I understand the Judge correctly, he says you could not gain possession against the State. If the State had not transferred its title to the individual you could not gain title by adverse possession. Do I understand that correctly?

JUDGE HOOKER: Well it is a fact that anybody who has the right to raise the question can successfully defeat a claim of adverse possession by showing that the State has not parted with its title.

Q. Then if the State had laid out a parcel of land, and had laid it out into streets and lots and blocks, and had not sold these streets to individuals, wouldn't the title still remain in the State for those streets?

JUDGE HOOKER: If the State had never parted with the land.

Q. If it had with the lots, and not the streets, wouldn't the streets remain?

JUDGE HOOKER: That raises a question which has been considered many times, viz.: Who owns the title to the streets in an incorporated village or any place where lots are platted,

and there is a good deal of variance of opinion in this State, whether the title is in the State, in the public, or the holder.

MR. MARHOFF: The case I have in mind is where no one individual laid out the property. It was University land and laid out by act of legislature, and streets shown on the plat, not dedicated as streets, were laid out upon this piece of land and lots were sold.

Q. Sold by numbers?

A. Yes sir, and I would like to know in this case, whether title to the streets remains in the State.

JUDGE HOOKER: I am unable to say what might be held about that. I might perhaps at this juncture, profitably say a word about this matter of investure of title in lots not granted by the State or government.

Ordinarily where a question of adverse possession arises, it is between two private persons, and if one has possession, the other could not put him out by showing that the State had not parted with its title, because that would show that he himself had no title anyway, while the other man had title by possession.

But this case might arise. A man might take possession of land while it yet belonged to the government and occupy it for a number of years. Then it might be deeded to someone else. He might remain on the land five years longer perhaps, and then assert his title of occupancy against the purchaser from government.

The point in the paper was, that the period of occupancy before the grant could not be treated as part of the time essential to establish occupancy. It must begin from the time of the grant and the grantee from the government, in such a case as that, could raise the question because then he has a title from the government and he could say that he had acquired his rights from the government and therefore had a right to raise the question. That is about the only way that question could arise. Except, perhaps, in some such case as you suggest.

MR. MARHOFF: The judge, no doubt, knows of the case I have in mind at Battle Creek. Some of the streets are entirely closed up. The question I had in mind was whether they could gain title by adverse possession if the State had not parted with the title.

JUDGE HOOKER: It is a general proposition that until the State parts with its title, no title by adverse possession can be obtained by anyone who subsequently buys of the State.

The proposition that adverse possession cannot be made the basis of a title for highways, might be applicable there, but what view the court of Michigan might take I am not prepared to say. In one case, they have held at variance with the other courts that a man can acquire by encroachment, a title.

COL. MUENSCHER: Wouldn't that partly depend upon the fact that when a private individual dedicates his property for the uses of a street he expects to give up everything.

JUDGE HOOKER: I do not see any difference in property. It is not uncommon for a man to acquire title to lands—that is for certain purposes, for flowage for instance—by reason of dams. They never claim title to land, they claim the easement. They claim a burden on the land, and that may be acquired by usury or occupancy, as well as the entire fee simple.

MR. APPLETON: Sometimes when farmers disagree about a boundary, the old land marks have been gone for years but we find trees growing up continuously right along a line, where they have grown up in the corners of an old fence, conclusive to a surveyor that the fence must have stood there from the very earliest. Now I want to know if that isn't sufficient evidence that that line has been there and cannot be moved?

JUDGE HOOKER: That is presuming you could not find any other evidence on the subject. I think I am safe in saying that an old fence, under circumstances such as you suggest, is legitimate and strong evidence of a line in that place, yet it has been pointed out in various instances, that such fences may perhaps have been put in the wrong place.

Q. Intentionally?

JUDGE HOOKER: Intentionally, and of course the question must be a troublesome one to surveyors. I have known surveyors to be quite out of patience that there should be a question about such a thing, and they had a great deal of reason, but it must depend upon a multitude of facts, which are different in different cases, and which, if the surveyor cannot get the parties to consent that he should be the arbitrator, must necessarily go before the statutory courts.

MR. HODGMAN: There was a very interesting question in connection with this, that came to my attention during the past year. There is a paper in Detroit, running a legal column. Some one wrote to know if the surveyor had any business to change an old line and the legal editor told them that nobody had any business to change a line.

Now I claim that the broad general statement made by the Detroit lawyer who knew nothing as to the facts in the particular case is false and misleading. It all depends on what the line is whether the surveyor has a right to run a different one, for that is all that is meant by changing lines. I never heard of a surveyor destroying or obliterating the marks of an old line. If the line in question is a line of the survey in accordance with which the land was sold then every surveyor who knows his business understands that his sole duty in such a case is to find, if he can, just where that line was actually located and not where it ought to have been. But if the line in question is not of the survey in accordance with which the land was sold but of some other and subsequent survey, then the case is reversed and it is his duty to find where the line ought to have been. He must then find where the true line is according to the best of his skill and knowledge. Otherwise he has no business to make any survey at all. He does not determine lines only as the parties accept them or the courts uphold them. If the lines are to be settled by possession the parties have no occasion for his services. In Michigan most of the lands were sold in accordance with the United States

survey and the lines of that survey are binding. But that survey did not locate on the ground the subdividing lines of a section. The law provides how those lines shall be located.

But most of the old surveys in accordance with which the earlier land owners occupied and built their fences on these subdivision lines were not made as the law directs. If a man owned a forty, as it is commonly spoken of, and called in the services of a surveyor to find his boundary lines, in a majority of cases he was not willing to go to the trouble and expense of dividing the whole section up into its aliquot parts to get the true boundary but chose rather to have the surveyor just run around a square forty acres, regardless of what the section actually contained or of the fact that his deed called for such a part of the section. In such cases as this it is the duty of the surveyor, when called on, to survey out just such lines as the deeds call for and do it in the manner that the law directs. If he is not to do this he has no business on the ground at all. If it locates the line at some different place than some former survey twenty or forty years old did, that is no concern of his, and that fact does not absolve him from the duty of doing his work legally and correctly.

JUDGE HOOKER: It seems to be superfluous to call a surveyor if the line is fixed and cannot be changed. I think as first stated, that the proposition that a surveyor ought not to change a line, might carry a good deal of force. We should all go slowly in obliterating traces of surveys, right or wrong. Many times we are very certain of a thing that is not true. And if it is not essential to getting at what he considers the true survey, I see no occasion to destroy the evidences of the former survey. I have no doubt that on the subject of running lines, anyone of you knows more than I do, but I have often wished I knew more, because where those cases have arisen in court, they have sometimes been very perplexing indeed and I have not always been certain that justice was done.

Q. Suppose that at sometime in the past, two adjoining property owners built a fence. There appeared to be some obstruction and on account of the obstruction, they built the fence off the line, both knowing and consenting to it. In the future could one of those men obtain title by adverse possession?

JUDGE HOOKER: They could claim it, because they do.

Q. Would it be adverse possession?

JUDGE HOOKER: I think not, under the distinction given in the paper. As I remarked, I might have found you a case right in point on that subject and upon a great many other subjects and I could have produced illustrations here by the cord, all applications of the doctrine of adverse possession, and some upon this question that you raise, but the general principle is that the parties must know that they are agreeing upon a boundary and if on the contrary, they are merely acquiescing or agreeing upon a line, until they shall get at the true one, or upon a line for their convenience, until it is convenient to put the line in the right place, there is no such agreement or acquiescence there as will amount to a title by occupancy, or make any foundation for it.

Cylindrical Needle, [reversible].

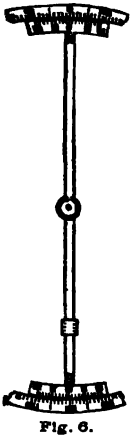


Fig. 6.

Needle with Vernier.

WHY DO DIFFERENT MAGNETIC NEEDLES NOT ALWAYS POINT IN THE SAME DIRECTION THOUGH OBSERVED AT THE SAME PLACE AND TIME?

BY C. LOUIS BERGER,

Of the Firm of Buff & Berger, Boston, Mass.

A close observer of the compasses used in surveying instruments must have noticed that the exterior shape of the magnetic needles, forming part thereof, frequently differs as much as do the styles of the instruments themselves. In some cases the needle consists of a bar of thin steel, oblong in shape, which rests flatwise on its supporting pin so that its greatest superficial area lies in the horizontal plane as shown in Fig. 1. In others, as represented in Figs. 2, 3 and 4, the shapes are modifications of the above in a greater or less degree, inasmuch as their longer transverse dimensions—whether at the ends or center—also lie in the horizontal direction. Some magnetic needles carry a graduated circle or verniers, as the case may be, as seen in Figs. 5 and 6, whose zero points are supposed to lie in the geometrical axis of the needle; some are placed edgewise so that the greatest superficial area lies in the vertical plane. There are also dipping needles to measure the vertical intensity of the earth's magnetism; short and stubby needles with aluminum extensions for galvanometers; complex needles, made in sections, used in marine compasses, and cylindrical or tubular forms used in scientific research. (Needles of the last mentioned type are not read by observing the ends but by means of mirrors attached at the middle similar to those on a magnetometer.) Figs. 9, 10 and 11 show the principal types of the last mentioned needles.*

* The largest and most delicate magnetic needle with which the writer is acquainted is that of the large magnetometer in the University of Marburg, made of a solid bar of steel two feet long and weighing about twenty-five pounds It was suspended from the ceiling by a strand of silk fibres and was provided with mirrors so that any oscillation could easily be read by the use of a scale and theodolite. This instrument was made after the style of Ganss' instrument and with many observations were made to determine the diurnal and annual changes in the magnetic meridian at that place during the younger days of the writer.

Since these latter forms are never met with in surveying instruments we shall not consider them here, except to show the different styles of needles in vogue—suffice is to say that some of the shapes are simply selected by their propounders for the larger superficial area which they have, compared with others, according to the purposes for which they are intended; for, it is well known that the larger the superficial area combined with a minimum weight, the more delicate will the magnetic needle be: thus, a needle made of a very thin steel tube will be capable of receiving and retaining a greater charge of magnetic force, and, also being very light, preventing wear of the cap and pin it is easily influenced to assume the direction of the magnetic meridian in azimuth.

However, we wish to remark here that it is not so important that the needle of a surveying instrument should have a great magnetic intensity up or nearly to saturation—which it may receive according to its superficial area and degree of hardness —as it is, that it should have as constant an amount as possible, be it great or small. Of course such a needle should have a surcharge, which it is apt to receive if improperly hardened, because its intensity is liable to be diminished and the needle thrown out of balance thereby, from time to time requiring a readjustment of its counterpoise for the same latitude in which it is used.

It is all essential that a well constituted needle should have a proper symmetrical form as regards the longitudinal axis and that it should be supported on a pivot as free from friction as it is possible for human ingenuity and skill to contrive. Besides the necessity of proper form and suspension, the quality and degree of hardness of the steel, length of the needle, and lastly the strength of its magnetic force, whether imparted by an auxiliary magnet or the more powerful electric battery and coil, have a most important influence on the behavior of a needle.

Returning to Fig. 1 we see exemplified the flat bar and in Fig. 7 the edge bar needle as used in surveyor's compasses,

but as all the intermediate styles of needles are simply modifications of the flat oblong form, in order to be light in weight, partaking of the same principle that is involved, we shall consider these two forms almost exclusively. It remains, therefore, for us to show in how far the exterior shape of a needle—whether of a faulty design or imperfect construction—may affect its reading, inasmuch as its geometrical axis, that is, the line passing through its ends and the center point in the needle cap may not coincide with its magnetic axis which lies in the plane passing vertically through its poles and in which the magnetic meridian is contained.

However, to get a complete understanding of the matter we must go back to the ingot from which the steel of the needle was produced. If we remove a portion of the outer crust of a steel ingot or outer casting and carefully examine the surface laid bare with a magnifying glass, we shall find that what seemed to the naked eye as a solid mass is now a spongy one with numberless small and large cavities or blowholes. It is only by forging and rolling into bars and sheets at the mill that the metal becomes at all homogeneous. Some of the cavities not being welded are elongated in the direction of the rolling and form veins, flaws or blisters according to size, thus imparting to the bar or sheet a structural grain or fiber, which, while always traceable in poor steel, can only be detected in degree when the ingot has been converted into fine steel. In the absence of information to the contrary it is therefore but natural for the writer to believe that when a needle is being magnetized its resulting magnetic axis will in all likelihood tend to run in the direction of the general trend of this grain without strict regard to the geometrical axis with which it may then be at an angle. The above divergence of these two axes may, therefore, be considered as one cause of the observed fact —*that two needles, though of the same size and shape, other things being equal, may not read exactly the same when observed at the same place and time.*

If, on the other hand, these two axes (magnetic and geometri-

cal) do coincide, there will be no deviation, and two or any number of needles will read alike under the conditions above mentioned if tested in the same compass.

Notwithstanding the fact that it is, in practice, very difficult to attain the desired result on account of the difficulty of tracing the grain, the writer would and does insist that the steel used in the construction of needles for surveying instruments shall not be forged but shall be cut from fine shear steel, in the direction in which it was rolled, and be treated in such a manner as to ensure as near a parallelism of the structural grain with the geometrical axis as possible. Yet in spite of the utmost care and skill consequent minor magnetic poles are probably present, and there is almost certain to be a deviation of these two axes, and this deviation will vary in magnitude with the quality of the material, the design, width and length, and the mechanical skill with which the outlines of the needle in azimuth has been made, as also with the degree of accuracy with which the point of suspension has been located in the geometrical axis.

While it may seem that just here the instrument maker's real work should begin in the testing and adjusting of these axes by grinding off a little from one side or the other, as the case may be, to insure a coincidence of the two axes, he, as a rule, will stop here either from lack of understanding or from want of necessary apparatus and a secluded space free from iron, and provided with well defined meridian marks established by means of collimators or natural objects. His chief reason for not doing this, however, may be said to be the fact that neither he nor the surveyor wish to bear the added expense. For this and other reasons the scientist, not wishing to depend upon mechanical skill for good results adopts the method of reversion, by means of which errors from this source can be entirely eliminated. Therefore, the needle used in his investigations (see Fig. A) can be reversed by simply turning the needle upside down (the cap having been changed from the top to the bottom side of the needle) on the center bearing point, so that

he can use the mean of the reading of each end in both the direct and reverse position as the result sought.

If the surveyor is desirous of making some such test he can do so readily, not by changing the center cap as above noted, for he cannot do so with American instruments, as the center cap is firmly fixed to the needle; but, by first taking a careful reading of both ends of the needle he can, by means of a strong magnet, reverse the poles of the needle,* and, after rebalancing, read again the two ends, thus obtaining a reading correct in a measure and approximately finding the constant of his needle, which he can use when needed for important work.

The constant of the needle is therefore *the angle that the magnetic axis makes with the geometrical axis.*

If a needle has aluminum extension arms as in galvanometers, Fig. 9, or a circle attached as in the case of prismatic compasses, Fig. 5, or if it is provided with verniers as in some compasses, Fig. 6, then the constant of the needle, or the index error, is the angle that the zeros of the graduations or extensions (supposed to be in coincidence with the geometric axis) makes with the mangetic axis. As a rule, needles of the latter type always do have such an index error in addition to those arising from eccentricity of graduation and the difficulty encountered by the maker to determine the magnetic axis.

While the methods of reversion for eliminating errors of eccentricity and non-coincidence of the principal axes just described are good for scientific research, they are ill adapted for the work of the surveyor.

A surveyor's compass is ordinarily graduated to single degrees and a fine instrument is seldom divided to read to less than one-half degree directy or from six to ten minutes by estimation; therefore it is useless to try to arrive at results closer than these. A needle will serve its purpose well if the two principal axes coincide within the degree of accuracy obtainable with its length and with the compass as a whole.

* Accidental changing of the poles by carrying the instrument on an electric car near the motor has been noticed by the writer, and has explained what, at first seemed to be, very queer behavior on the part of the needle.

The following question may now properly present itself: What is the best form for a magnetic needle for the surveyor in order that it shall be so nearly free from errors due to the above causes as not to require reversion and yet to come within the degree of accuracy obtainable in practice? If now we have recourse to Fig. 1 and such modifications of the shape there shown as is delineated in Figs. 2, 3 and 4, we shall see that since the greatest superficial area lies in the azimuthal plane, deviations of the two axes cannot be infrequent and, therefore, these shapes are not well adapted for surveying instruments. Fig. 4, in particular, presents the curious combination of a large surface at the ends and a small one at the hub. This increased spread of surface by the arrow shaped ends renders the needle especially liable to this defect without so much as compensating for it in greater magnetic intensity as was probably the supposition, since the arms connecting it with the central hub are quite narrow and limit the magnetic intensity. This faulty design is probably based on the supposition that, since in a well hardened and well constructed needle the magnetic intensity is greatest at or near the extreme ends, gradually weekening towards the center, where it becomes quite indifferent, that if the ends are made big the needle will the more readiy assume the magnetic direction.

On the other hand, the edge bar needle, as shown in Fig. 7, with its greatest superficial area in the vertical plane, reduces the chances of a non-coincidence of the two principal axes in the azimuthal pane to a minimum. In order to add strength and stability to this needle it is made thicker at the middle than at the ends, which are quite thin.

If in the manufacture of a needle of this form the arms are bent so as to be symmetrical to the axis passing through the center of the needle cap and at right angles to the line connecting the ends of the needle, as shown in the exaggerated diagram, Fig. 8, the magnetic axis will be contained in a plane parallel to the vertical plane passing through the ends of the needle and a little removed from it.

The error in the reading introduced by this small distance will be very small compared with the error due to the eccentricity caused by the above mentioned bending. But, supposing the case that in a badly constructed needle of this class one arm is bent more irregularly than the other so as to unsymmetrically distribute the mass of the metal of the needle, then the resultant polarity consequent upon the irregular distribution of masses of the metal, may be slightly at an angle to the line passing through the ends of the needle, causing an error due to the divergence still very small as compared with the error due to the eccentricity such a needle would have.

So far in the foregoing explanation we have dealt with the magnetic needle alone. It will now be necessary to treat this task in relation to other functional parts that go to make up a surveying instrument since there are other causes, which, singly or combined, may conduce to produce the differences mentioned in the reading of different needles.

However, before dealing with this subject in its further complexity in relation to the compass and instrument, we first of all take it for granted that there be no local attraction in the instrument itself, or by any iron concealed on the person of the observer.*

Next we assume that the graduation of the compass is a good one, and that the pivot on which the needle rests is in the center of the graduation and that both ends of the needle read precisely 180 degrees apart. Next, that the needle will be so sensitive that when deflected from its pointing by the outside attraction of a piece of iron held about a foot or so away from it, will settle to its original position several times in succession. This sensitiveness depends on the form and sharpness

*To determine whether an instrument itself has any iron it to disturb the needle, it is a good plan, after setting the transit so that both compass needle and the vernier read zero, to go around the circle, setting the vernier ahead ten degrees each time, and noting whether the compass needle also describes an arc of precisely ten degrees. If it does not, there is some local attraction. Before making this test it will be well to first test the needle as to sharpness of pivot—mentioned later on—and to breathe on the glass cover of the compass and on the rubber frame of the reading glass so as to remove any electricity which may be present. Both of these articles being insulators are very easily electrified by the process of cleaning in a dry atmosphere, thereby affecting temporarily the reading of the needle.

of the pivot, strength of its magnetism and its bearing upon the finely polished jewel or steel cap. (*It is generally owing to the dulling of the point and the scratching of the cap that a needle becomes sluggish and refuses to return to the same point.*)

Then the extreme ends of the needle should come close to the graduation and, together with the point of suspension, lie in the same plane with it, so as to avoid parallax in reading. It is also important that the center of gravity of the needle be as far below this plane as possible in order that the quivering of the needle, so necessary to insure the proper settling of the needle on the pivot, shall not be annoying. If the extreme ends of the needle and the point of suspension are in the plane of the graduation, the quivering motion will not be annoying since the extreme ends lie in the axis of quivering and consequently are stationary, as shown in Figs. 3, 4, 7 and 9. In Figs. 1 and 2 the plane in which the needle and its ends are contained is much below the axis of quivering which lies in the point of suspension and in consequence such needles can only be read when they have ceased quivering.

With a compass constructed as above we see no reason why its needle or any number of needles of the same shape as shown in Fig. 7 should not give the same reading as long as the compass and its immediate surroundings remain undisturbed.

Our task of showing that in a theoretically perfect compass the needle will always assume magnetic north and south—debarring erratic oscillations due to earth currents—would therefore seem to be ended were it not for the fact that in a surveying instrument a sighting arrangement, telescopic or otherwise, must by provided, by means of which natural objects can be viewed and their relative positions in azimuth determined with regard to the stationary pointing of the needle in the magnetic meridian, affording a means for measuring angles and tracing lines. Seen from this standpoint, it is therefore all important that the plane passing through the slits of a surveyor's compass, in which the line of sight is contained,

be truly in line with the zero points of the graduated ring and at right angles to the plane of the same. With the transit, the line of sight, as defined by the optical axis of the object glass and the cross wires of the telescope, must not only revolve in a vertical plane in which the line of collimation is contained, but this vertical plane must also either cut the zeros of the graduations or at least be parallel to the plane passing through them. This condition is, however, so difficult of attainment in instruments fitted with a telescope, and in cases where it may exist it is so very apt to become deranged, that the writer is sure that right here the principal cause can be found for most of the differences observed in the reading of the needles of different instruments, though observed at the same time and place. To illustrate this, suppose we bisect a distant natural object with the cross wires of different instruments whose lines of collimation are in perfect adjustment, then the readings of the needles—assumed to have both of their principal axes in coincidence—would be the same if the zero points of the compasses are contained in the vertical plane of the line of sight. But, if on the other hand, the initial points of the compass are not contained in the vertical plane of the line of sight the reading must differ by an amount equal to the angle of this divergence in any one of the different instruments. This index error, while often of no account in ordinary instruments will exist nevertheless, and must always be looked for even in the best class of instruments, since in the field use of an instrument and by rough handling it is very liable to change.

This is particularly the case where a telescope is involved, since in its construction we have to deal with the optical axis, which, of itself, is of a very complex nature and subject to changes affecting its line of collimation in relation to the compass, and because of the changes occurring by rough handling in the position of the standards carrying the wye bearings of the telescopic axis of revolution in the customary instruments. Therefore, in order to eliminate all the errors due to the change of the line of sight with regard to the zero points of

the compass, the instrument should be tested before any important work is undertaken with the needle.

Before proceeding to determine the index error or constant of the compass of a transit, it will be well to verify the adjustment of the line of collimation as well as its motion in the vertical plane. Then, having previously established a meridian line by three points in line, point the telescope to the mark at the north, read the needle at both ends, and, in order to eliminate all errors of eccentricity of the graduation or needle and thereby arrive at correct results, the instrument should be reversed on its vertical axis and the telescope again pointed to the mark at the north end as before and another reading taken from both ends of the needle.

The average of the four results will be the combination of both the index and magnetic errors and that of the declination of the needle, the latter being the angle the magnetic meridian makes with the astronomical meridian at the place of observation. Naturally then, in a theoretically perfect instrument the reading of a needle at a place where east and west declinations join, would be zero when the cross wires bisect the meridian mark. However, as in the field use no instrument will retain its fine qualities and adjustments, it will be best not to depend on them, but to determine the index error and constant of the needle combined simultaneously, from time to time, by an observation on a meridian as above described, in order to apply it as a correction in precise work. In instruments fitted with a variation plate permitting the declination for any particular locality to be set off, the combined errors of the instrument and needle can at once be added to or subtracted from the declination, as the case may be. But, as these constants differ in every instrument it furnishes the explanation to the question propounded in the title of this paper—Why do different magnetic needles not always point in the same direction though observed at the same time and place?—*unless these constants have been previously determined and applied in every case.*

There are other reasons, such as the daily variations of a needle, which, according to temperature, latitude and season of the year, may amount to from six to sixteen minutes alone, showing why reliance on the reading of a magnetic needle can be placed only within certain limits and that it should be depended on only for general direction as required in filling in details. For exact work meridian lines run by solar or stellar observations should be depended on exclusively, to which end the modern solar attachments give the fullest satisfaction.

In conclusion, we would say that such tests on a meridian mark, as recommended above, should be repeated often, and that in order to facilitate the work such meridian marks should be located at some convenient place so as to be within easy reach of the surveyor at all times.

In the selection of such a place care should be taken that there is no iron in the vicinity and that there are no electric wires, particularly those used for arc lighting or the conveyance of power within a radius of three to six hundred yards, or else a needle is apt to be affected by these currents as would be the needle of a galvanometer. Such a place, if properly selected and provided with permanent meridian marks, could at the same time be made available for verifying the telescope and level adjustments of the transit so necessary to its proper use. For the benefit of surveyors the city of Boston many years ago provided such meridian marks on stones deeply set into the ground on Boston Common. Unfortunately, electric wires now pass all around these grounds and even traverse them so that no reliance can be placed any more on observations there made.

The above remarks have been cheerfully written at the request of your secretary, and, while there may be differences of opinion with regard to some of the points set forth, the author has simply endeavored to embody in them the observations and results obtained in a long practice.

DIFFERENCE IN MAGNETIC NEEDLES.

L. BECKMANN.

Engineers are often puzzled when they find that different transits placed on the same point, under exactly the same conditions, with needles settled at zero, do not point on the same object through the telescope.

This difference is strictly mechanical, as every magnetic needle will, in the same place at the same hour, take the same direction, under the sole influence of the earth's magnetism. This can be easily proven if we would take three or more magnetic needles of exactly the same length and same height of center and replace them in a compass box with limb clamped, they will all take the same position, provided they are well adjusted and the instrument be not disturbed in changing from one needle to another. That the telescopes do not point on the same object in the respective instruments to which these needles belong is because it is almost impossible for the maker to make the line of collimation mathematically coincide with the north and south line of the graduation of the compassing.

Let us see how the maker proceeds when he lays out the vernier circle of a transit. First, he divides the circle in four parts, representing N., S., E. and W., parallel to the north and south line and equidistant therefrom he marks the lines where the holes for the standards are to be drilled. Let us suppose that two of these holes, the two on the north side of plate, being 1-100 of an inch to the east so it would throw both standards that much out of parallel from the north and south line of the graduation. This would amount, if the base of standards is 4 inches long, one inch in 400 inches, or one foot in 400 feet. As in most factories the holes of the vernier plate are laid out by steel plates, laid out with great care, we will find that the same kind of instruments of the same maker will

coincide better with each other, as when compared with those of other makers. Now let us follow the maker when he puts on his standards, he marks on the base of the standards the holes for the screws to hold them on the vernier plate; if he does not get these holes exactly parallel to the sides of the standards, there is another error that may throw the telescope out of the north and south line of the instrument. Now we come to the bearings of the telescope axis. The standards after being planed off are soldered together and filed that way, and the center line for the telescope bearings marked on. The cover of the bearings fastened on and the holes drilled for the telescope bearings. If the hole would be the least of the line, there would be the third cause to throw the line of collimation to the right or left. Another error may occur if the two bearings of the telescope are not exactly at the same distance from the center of telescope, but as this is easily avoided by careful workmanship, this will rarely happen, but the least difference will throw the line of collimation out from the center of telescope. Now, if the telescope does not stand exactly at right angles to its center, this would be another cause of error, but this is not apt to occur by careful workmanship. When the vernier circle is placed on the graduating machine, we have to see that the cutting knife cuts exactly on the line marked for north and south, or all pains taken before would be of no avail.

From these few remarks you will see that it is almost an impossibility to get the telescope to swing exactly in the same plane as the lines marked on for north and south; all we can do is to use the utmost care in every part of the instrument.

As a curiosum I will mention that the lawmakers of Ohio have established a law that the county surveyor in each county shall find the variation of the magnetic needle every 30 days, so that the other surveyors can regulate their compass to his findings. It is a good luck that this law is not complied with, or the Ohio surveyors would have a big job on hand every 30 days. It is sometimes complied with in those counties where a true meridian is established, but the best that such surveyor

will find is the variation of the particular instrument with which he makes the observation. There are some instruments in use in the United States coast survey built and constructed exclusively for the purpose of ascertaining the variation of the needle, but the description of these instruments is out of the range of this paper.

Troy, N. Y., U. S. A., December 21, 1894

F. Hodgman, C. E., Climax, Mich.:

DEAR SIR—Referring to your letter of the 15th October we have made a series of experiments with the magnetic needle and enclose herewith some conclusions as well as a condensed statement of the observations.

If you wish we can give you the full series of observations in detail, but we do not send it now as we think it possible that this may be all that you care to see.

The observations were made by our Mr. E. W. Arms, one of the most critically careful men that we have ever had in our employ.

We find that different magnetic needles will not point in the same direction at the same time and place, neither will the same needle point in the same direction at different times.

The construction is not necessarily faulty, but it is practically impossible to have the magnetic axis and the geometric axis of the needle coincide, and the varying conditions of the atmosphere influence more than is usually supposed.

Eight needles were tried on the same center pin on eight different days at 8 a. m. and at 1 p. m.

They varied at the same time from eight to fifteen minutes.

The diurnal change was from two to nine minutes and we have observed it as much as fourteen minutes.

Three (3) needles had their greatest breadth horizontal.

Three (3) needles had their greatest breadth vertical.

Two (2) needles were the straight bar pattern.

The method of reading was to bring the needle to coincide with one division and read the vernier of limb; then set on another division and read vernier again.

Any pair of readings differing from each other more than two minutes were thrown out and the observation was repeated.

	Average readings of eight needles.		Atmospheric condition.
	A. M.	P. M.	
Dec. 11....	12 deg. 53 min.....	12 deg. 50 min.....	Sleet and drizzling rain.
Dec. 12....	12 deg. 53 min.....	12 deg. 53 min.....	Steady rain all day.
Dec. 13....	12 deg. 56 min.....	12 deg. 47 min.....	Windy, warmer, clearing.
Dec. 14....	12 deg. 55 min.....	12 deg. 48 min.....	Cloudy, light rain.
Dec. 15....	12 deg. 37 min.....	12 deg. 41 min.....	Frosty and clear, needles read more alike than any other day.
Dec. 18....	12 deg. 55 min.....	12 deg. 48 min.....	Very clear, colder.
Dec. 19....	12 deg. 49 min.....	12 deg. 46 min.....	Clear, still colder.
Dec. 21....	12 deg. 56 min.....	12 deg. 49 min.....	Dense fog, clear afternoon.

We trust that this will be of interest to you and waiting your reply we are

Yours very truly,

W. & L. E. GURLEY.

In making the observations of the mangetic needle, as desired by Mr. Hodgman, secretary of the Michigan Engineering Society, we take the proposition to be: "Can the needle be relied upon by the ordinary surveyor for exact observation?" It may be well to state the conditions under which the tests were made by us.

The instrument used was the plain Engineers' Transit with five-inch needle; the place selected for the test was a basement in a building in a quiet part of the city, the basement concreted and entirely empty, containing only the instrument used in the test. The door of the room in which the instrument was placed was locked, and no one had any entrance into the room except the observer.

The eight needles used were three flat needles, three needles having the greatest width vertically, and two bar needles. These needles were made by the same man, and from the same sheet of steel. In the test the eight needles were used on the same center pin.

The method of observation was this: The limb being set at zero and the telescope of the instrument focused on a known point, the upper plate of the instrument was then unclamped and moved around until the zero of the compass circle came into coincidence with the needle; the variation was then read off upon the limb, and one or two more observations were made with a view of definitely ascertaining if there had been any error in reading.

It may thus be said that even if the telescope should not be in line with the zeros of the compass circle, no difference in observation could be made; as a matter of fact, by our method of adjustment the telescope is brought precisely in line with the zeros of the compass circle.

We now desire to make two points in regard to the working of the mangetic needle, and prove them if we may by the observations as made above. The first proposition is, that the same needle on the same instrument does not point in precisely the same direction on different days. Some days there seems to be an unusually magnetic attraction, as for instance on December 15, a clear frosty day, the average variation in the morning is from fifteen to twelve minutes less than the average morning variations for the seven other days of the observation. The average afternoon variations on December 15 is from eleven to six minutes less than the average afternoon variations for the seven other days of observation.

Taking needle No. 1, we find that on December 11, with sleet and drizzling rain, there was a variation of fifty-one minutes in the morning, and in the afternoon a variation of forty-nine minutes, a difference during the day of two minutes. On the 21st of December, a dense fog in the morning and clear in the afternoon, No. 1 needle gave a variation in the morning of sixty-two minutes and in the afternoon of fifty-three minutes, making a change during the day of nine minutes.

Taking needle No. 8, which was a bar needle, on the 14th of December, cloudy and light rain, this needle gave a variation in the morning of sixty minutes and in the afternoon of forty-seven

minutes, showing a change during the day of thirteen minutes. On the 19th of December, clear and cold weather, the same needle gave a variation in the morning of forty-eight minutes and in the afternoon of forty-five minutes, making a change during the day of three minutes.

Taking needle No. 4, a vertical needle, on the 12th of December with a steady rain all day, this needle gave a variation in the morning of fifty-seven minutes and in the afternoon of fifty-six minutes, making a change during the day of one minute. On the 18th of December, very clear, cold weather, needle No. 4, gave a variation in the morning of sixty minutes and in the afternoon of fifty-one minutes, making a change during the day of nine minutes.

We think these figures will prove definitely our proposition as stated above, that the same needle does not indicate the same variation on different days. Our second proposition is: That different needles do not indicate the same variation on the same day.

Taking the observation on December 19, needle No. 2 in the morning gave a variation of fifty minutes, in the afternoon of forty minutes, a change during the day of three minutes. Needle No. 5, a vertical needle, gave a variation in the morning of forty-five minutes and in the afternoon of forty-one minutes, making a change during the day of four minutes, and a difference with needle No. 2 of five minutes in the morning and six minutes in the afternoon. Taking needle No. 7, a bar needle, we have in the morning a variation of fifty minutes and in the afternoon a variation of forty-five minutes, making a difference during the day of five minutes, and being exactly the same variation as needle No. 2 in the morning, while in the afternoon there is a difference of two minutes between the two needles, and a difference of five minutes with No. 5 in the morning and four minutes in the afternoon.

We might state that in these observations degrees were disregarded, and the observation simply taken by the minute.

The morning readings were taken between 8 and 8:30 o'clock, and the afternoon readings between 12:30 and 1 o'clock.

MAGNETIC NEEDLES.

Results of observations with eight five-inch needles on the same center pin.

Method—By the upper tangent screw of a transit, a graduation of the compass circle is brought into coincidence with the needle and the reading to nearest minute taken from vernier of limb. This is repeated on another graduation, and if the reading varies two minutes, is discarded and tried again. Temperature of room practically constant.

Date 1894	Dec. 11.		Dec. 12.		Dec. 13.		Dec. 14.		Dec. 15.		Dec. 18.		Dec. 19.		Dec. 21.		Dec. 24.	
Weather	Sleet and drizzling rain.		Steady rain.		Windy, warmer.		Cloudy, light rain.		Frosty, clear.		Very clear, colder.		Clear, still colder.		Dense fog.		Clear.		Very cold.	Much warmer.
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
No. 1, flat needle	51	49	55	52	60	50	55	51	39	44	59	50	52	49	62	53	55	49
No. 2, " "	55	53	56	54	65	56	57	50	37	40	55	45	50	47	55	51	56	44
No. 3, " "	52	47	60	57	63	51	56	50	40	45	60	50	54	51	60	51	53	48
No. 4, vertical needle	52	50	57	56	61	48	55	48	38	43	60	51	50	48	54	51	52	46
No. 5, " "	---	---	49	48	47	40	52	44	35	38	50	45	45	41	54	46	50	41
No. 6, " "	---	---	46	42	47	42	56	45	34	35	56	45	47	42	56	50	53	44
No. 7, bar needle	---	---	---	---	53	46	60	48	38	40	58	47	50	45	51	49	55	45
No. 8, " "	---	---	---	---	56	49	60	47	35	38	56	50	48	45	50	45	53	46
Mean	53	50	54	51	56	48	56	48	37	40	57	48	49	46	55	49	54	46
Max. variation from mean	2	3	8	9	9	8	4	4	3	5	7	3	4	5	7	4	4	5
Max. difference	3	6	14	15	16	16	8	7	6	10	5	6	7	10	12	8	8	8

The a. m. readings were taken between 8 and 8:30 o'clock.
The p. m. readings were taken between 12:30 and 1 o'clock.

W. & L. E. GURLEY,
By E. W. ARMS, C. E., Observer.

Troy, N. Y.

DIFFERENCE IN MAGNETIC NEEDLES.

F. HODGMAN.

I was called in 1869 to locate a boundary line along the center of an angling road in Kalamazoo county. The record of the road survey was essentially as follows: "Commencing at the guide board tree on the county line and running thence S. 66°, W. 68 chains, thence S. 52°, W. 26.87 chains to the center of an old road this day taken up. Surveyed June 4, 1839. Chas. Merritt, surveyor. Var. 4° from the U. S. survey." I found the guide board tree standing, set my instrument in front of it and turned off S. 66° W. The line would have left the road in less than 80 rods, and yet there was plenty of evidence at hand to prove that the road was just where it was laid out and always had been, save for a few encroachments here and there, especially the one a mile away which was the occasion of my being called out. I tried every theory I could think of, but not one of them would locate a line which would not leave the road entirely before reaching the point in controversy. I gave it up for a bad job and advised the parties to call out the road commissioners and have them locate the line of the road definitely, mark and record the location, and let that settle the dispute. Accordingly the commissioners were called out and located the road on the line as actually occupied as nearly as practicable. Another surveyor and myself were employed, he because he was an old surveyor familiar with the surveys in that vicinity, and I because I was the county surveyor. We located the west end of the 68 chain course by placing a monument in the center of the traveled road, and then set up our instruments and sighted to the guide board tree. When we compared notes as to the direction, we found a difference of 20 minutes. We then set the instruments as closely together as practicable on the line, sighted them both at the same object

in line, and compared courses with the same result as before. We then tried reversing the sights of each instrument in turn and then both together. These changes made so little difference in the result that it remained practically the same. I was then young in the business, and relying on my text books I had supposed that having the course of a line by the original survey, and knowing the annual change in declination of the needle and the time that had elapsed since the original survey, that I ought to be able to retrace the original line by the needle. But this, to me, astounding fact that had suddenly shown itself, at once and forever banished that idea from my head. If Mr. P's instrument and mine differed 20′, what could be more likely than that one or both of them differed from Mr. Merritt's instrument, and who was to tell how much and in what direction that difference was? Since then I have had a number of opportunities of comparing different instruments, and though I have kept no record of the results, I can say in a general way that I never tried two that were exactly alike. About eleven years ago, January, 1884, I attended a convention of the Ohio Surveyors' Association, in which they were discussing the results arrived at in endeavoring to find the true declination of the needle in different parts of the State, and incidentally to locate the isogonic lines in that state. These results were so inharmonious and discordant, especially in comparing observations in stations only a short distance apart, that I think that society gave up the whole matter for a bad job—except as it demonstrated the unreliability of the magnetic needle for retracing old lines, and so was of value in geting rid of some bad laws that were in the Ohio statutes. It was at that meeting (5th Ohio Report, p. 74) that Mr. L. E. Gurley called attention to the difference in needles and made the statement in regard to a test that he had made which is referred to in my Manual of Land Surveying, p. 27. I have no doubt the discordant results obtained by the Ohio surveyors are in a measure to be accounted for by the difference in the instruments used. There has been a great deal of time,

labor and money spent in magnetic observations with a view to utilizing them for the use of surveyors. We have been taught the long story of the various changes in direction of magnetic needles caused by influences outside of the compass and needle itself, and have been taught how to compensate for them.

But here comes in another important source of error that we have been left to find out for ourselves. Some of us had discovered it. Many had not. Those who had are worse off than they were before. *Then* we could go on using the needle to re-locate lines of old surveys in all the self-confidence which ignorance inspires. We could claim that we were doing just the right thing, and prove it by the text books and authorities. *Now* we know that there is another probable cause of error and do not know how to correct it. Mr. Berger has shown that the error may be either in the needles themselves or in the other parts of the instrument, and that when these other parts are brought into their proper adjustments with the needle that they will not stay so for any length of time.

Mr. Gurley has shown that the difference in direction between two needles is not a constant one, but varies with the weather, the season and the time of day. Apparently the same causes produce greater effects on some needles than they do on others.

It is not possible to find out how my compass compares in direction with that used by Mr. Merritt when he surveyed that road in 1839, for he only fixed one point in the line, viz., the guide board tree. His old compass is probably not in existence now, but if I had it, an examination of it now would not disclose with any certainty what its condition was then.

What is to be done about it?

Stop putting more faith in the needle than the facts warrant. Many of us reached that point long ago. Others have not.

Settle the old lines the best way you can, whether by agreement between owners or by law suit. When settled, no matter how, fix the location of the lines by the best and most endur-

ing monuments the case will permit of. Make and preserve a complete record of them. When making original surveys for boundary lines mark the lines and record them with equal care and thoroughness. So long as your monuments remain in their places and can be found, you have an unfailing test which will effectually settle all these questions about changes in direction of the needle and of difference between needles.

Discussion of Papers on the Difference in Needles.

MR. RANDALL: I know that by laying a compass away, that I do not use very much, without reference to which way the needle points, it will require adjusting. I now clamp the needle at a certain angle, in the box, and have a certain place to lay the box, so that the needle may lay in the magnetic meridian, to preserve as much as possible the magnetic intensity of the needle.

You might conduct very careful experiments, lay away the needle carelessly and take it out the next day, and conduct equally careful experiments, and if you did not take into consideration the place where the needle had lain, there would be very little gained.

The fluctuations in the direction of the magnetic meridian are so small that it is of little consequence, and yet we like to have as much magnetic intensity as possible in the needle.

MR. STRONG: Doesn't it follow from the experiments of Mr. Gurley that it is important to make the record show the variation of the line from the magnetic meridian? The true meridian is a fixed quantity, a man's line is also fixed, and the distance between them is the thing we should record. At home we have a meridian fixed. We set up our instruments in the morning, and take the bearing before we go, and carry it on the needle. And we go out and swear that there is just so much variation from the true meridian, because we compared our instruments in the morning. Is there any use of this?

MR. SEARS: I have frequently run ten miles of tangent with the compass through the forest, running all the time, for

three or four days. Then I would go back and project a perfect tangent line, and find myself from two to four or six rods from that first line—sometimes on one side and sometimes on the other. I had run a system of zig-zags, and comparing my rods, I would find a variation all the way from six to twelve and fifteen minutes.

Where you rely upon a compass at all, a good plain compass is way ahead of a transit, because on the transit the build and position of the telescope is such that you cannot get a good reading with the needle.

CEMENT AND CONCRETE.

V. S. HILLYER.

In the proceedings of this society the important subject of hydraulic cements and concretes seems to have been omitted. Though cements of a quality inferior to those now in use have been known for centuries, and though ancient arch bridges and viaducts still stand as evidences of the good qualties of the cement and skill of the engineers, still the present advanced state of the art has been developed during the past fifty or sixty years. Instead of using lime concrete only in the poorest and cheapest foundations, cement concrete is now used in the most important of engineering works. There is hardly a position in which masonry has ordinarily been used that concrete has not been successfully substituted. Ocean breakwaters, dams, retaining walls, bridge piers, arch bridges, fire proof floors, walks, street pavement foundations, reservoirs, tanks, chimneys, sewers, culverts, building foundations and even whole buildings—all—have been made of concrete and have given entire satisfaction in their stability and permanency.

At this time hydraulic cements are divided into two general classes, viz.: Portland cement, and natural, or Rosendale, or American, or Roman, cements. The Portland cement, as a rule, is an artificial mixture of the ingredients, while the latter class is usually made from the quarried limestone. The production of the natural cements, as we know them, was begun in Great Britain about one hundred years ago and in this country about 1837. Though the details of the manufacturing plant have changed, the same general plan and the same principles of manufacture are followed today. Limestone rock is broken to suitable sizes, burned in kilns a few hours, ground to powder and put on the market. The manufacture of Portland cement began in Great Britain about 1843 and in this

country about 1875. Carbonate of lime and clay are intimately mixed in a fine condition by grinding together and moistening, molded into balls or bricks about two inches in diameter, burned to a point just below vitrifaction, again ground to a fine powder, air slacked, and packed for sale.

Except in the process of manufacture there is no well defined distinction between Natural and Portland cements. A good Natural may be better than a poor Portland cement. In general, however, the latter may be regarded as being twice as strong as the former, requiring five to ten times as long to set, and weighing half as much more.

Table one gives roughly the chemical composition of Natural and Portland cements:

Table One.

	Portland.	Natural.
Lime	63 %	43 %
Silica	22 %	25 %
Alumina	9 %	10 %
Iron	3 %	3 %
Impurities	3 %	19 %

It may be remarked, that the nearer a Natural cement approaches a Portland in composition and details of manufacture, the more valuable it is. Natural cements would be greatly improved by burning for a longer time and at a higher temperature, but this would increase the difficulty of grinding and add to the cost. The materials from which cement can be made are to be found in nearly all parts of the country, but the difficulty of grinding and mixing clay with the hard limestone is probably the reason more manufacturies have not been established in this country. In Europe, a soft limestone or chalk is used, and in England the mud from the rivers furnishes the clay.

Probably as much credit is due to Mr. John Grant, an English engineer, as to any other one person for improving the standard of quality of cement. Such immense quantities were used under his direction that manufacturers vied with each other to supply cement fully up to and above the high standard he specified. The usual tests for cement are for strength,

soundness, fineness, weight and activity. In some cases it might be advisable to specify a chemical analysis, but rarely. In conducting tests of cement considerable care and experience are necessary in order to obtain anything like uniform results.

The strength test usually consists in breaking by tensile stress, in a suitable machine, briquettes, one square inch in section, part of the briquettes being composed of clear cement, and part of cement and sand, in the proportion of one cement to two sand for the Natural, and one cement to three sand for the Portland, these proportions being measured by weight. In preparing the test briquettes the ingredients should be thoroughly worked, and only sufficient water used to make a stiff paste, as surplus water retards the setting, and the strength in the short time test is thus reduced. The briquettes being prepared in the molds, are allowed to set, then immersed in water the prescribed length of time before testing; one, seven and twenty-eight days being the usual periods, and the increase in strength between these several dates is a comparative indication of the final strength. It is perhaps improper to speak of the "final" strength of cement, as it appears to increase with age. By its final strength will be meant, in this article, that which is attained when ten or twelve months old. The increase of strength after this time is very slight and unimportant. The temperature in which the briquettes are made and kept should be about sixty degrees Fahrenheit, and if they are taken from the water to dry on the last day they should be kept in a cool place and dried slowly, as a sudden drying has a very injurious effect. This danger would be avoided if the tests were made directly from the water. A low temperature retards the setting very greatly, but does not effect the final strength. It has been recommended by a special committee of the American Society of Civil Engineers that a standard sand be used in making tests; a crushed quartz sand that will pass sieve number twenty and be retained by sieve number thirty.* A great many engineers object to using a standard sand. Of

* Sieves are designated by number, the square of their number showing the number of meshes per square inch.

course the cement to be used is that which gives the best results when tested with the sand to be used in the work, but a standard sand is necessary in order to compare tests made at different times and in different places. Though much has been written in regard to accurate standards and tests, no specification for the water has received much attention, salt water, rain water, or simply clear water having answered the purpose, and yet for short time tests the effect of using the different waters is very pronounced. In making tensile strength tests the sudden application of the load should be avoided, as the briquette will break under a much smaller load gradually applied.

Table two illustrates this and is given by Mr. Henry Faija, an English authority:

Table Two.

Rate.	Strength.
100 pounds in 120 seconds	400 pounds
100 " " 60 "	415 "
100 " " 30 "	430 "
100 " " 15 "	450 "
100 " " 1 "	493 "

The special committee above referred to recommend that beginning with zero the load be applied at the rate of 400 pounds per minute, or what is the same thing in the table, 100 pounds in fifteen seconds. The rate at which the load is applied is automatically regulated in some machines.

The tensile strength per square inch of first-class cement mixed with various proportions of sand should be at least as high as those given in table number three.

Table Three.—Tensile strength of test briquettes one sq. inch in section.

	1 day.	7 days.	28 days.
PORTLAND.			
Clear cement	120	400	500
1 cement, 3 sand	---	100	160
NATURAL.			
Clear cement	60	130	200
1 cement, 2 sand	---	60	110

The test for soundness is to determine whether a cement will expand and disintegrate after induration has begun and is no

less important than the strength test. The so called "Blowey" property of cement may be due to uncombined lime, to magnesia, or to sulphate of lime. For the two last mentioned causes there is no remedy; but air slacking or "cooling" will effect a cure for the uncombined lime. This test consists of making on clean glass, small, flat pats of clear cement, one-quarter to one-half inch in thickness at the center and with thin edges. When set, several of these pats are kept immersed in water for at least 24 hours, and should show no cracks, and the edges should be firm and not frittered away. Should yellow blotches appear it would signify too much clay. Should this test at first prove unsatisfactory, the cement should be thoroughly air slacked and again tested, when it may be found to be all right. The longer time taken for this test the more reliable and valuable it is. Immersing the pats in water at a temperature of 110 to 112 degrees Fahrenheit will hasten the settling and be more severe and reliable in its results. Some enigneers have strongly urged the use of what is known as the "hot test" for soundness. This consists of exposing the pats to a temperature of about 180 to 200 degrees Fahrenheit for several hours, then immersing them in boiling water several hours. A cement that will stand the hot test is undoubtedly good, but many cements proven to be equally good will not stand this test, and hence its adoption has not been general, and is hardly to be recommended. Even though a cement will stand the test for soundness it may be improved with air slaking. There is quite a general impression that only fresh cement should be used, but Portland cements have been kept more than two years and lost none of their good qualities. However, they must be kept perfectly dry, and do become somewhat slower setting. Cement that has lumped, of course, is not good. The engineer commissioners of the District of Columbia buy large quantities of cement direct from the manufacturers and supply it to the district contractors as wanted, from the storehouses.

The fineness of a cement is more a measure of its economic value than of its inherent strength. The finer a cement the greater its capacity for sand. The fineness and weight might be called correlative standards; one should not be given without the other. A fine cement could be produced by supplying to the mill-stones an underburnt and soft compound or rock, but underburnt cement weighs less than that which is properly burned. Some cements that weigh one hundred pounds per bushel could be burned so as to weigh one hundred and twenty-five pounds and be almost twice as strong. However, the more a cement is burned the harder it becomes and more difficult to grind. American Portlands, as a rule, are finer and heavier than imported, but all should pass at least 93 % through sieve number fifty and 88% through sieve number one hundred, and some American Portlands will even pass 96 or 97% through sieve number one hundred. The imported Portland will weigh 106 to 112 pounds per bushel, and American as high as 118 pounds per bushel. Were a cement ground to an impalpable powder it would be improved. One that feels like flour is preferable to one that feels gritty. A coarse cement, when tested clear, gives a higher tensile strength than a fine one, but when mixed with sand the finer gives the greater strength.

The test for activity determines the rapidity of setting. Cements are sometimes divided into two general classes, rapid and slow setting; the Natural cements being as a rule the rapid setting. There are several methods in vogue for determining relative periods of hardening, but as the time of initial set is the most important it only will be described. When a pat of cement is mixed with the smallest amount of water and then allowed to set, moisture first appears on the surface, but shortly after seems to be absorbed by the cement. When this water is absorbed, it denotes the moment of initial set, viz.: when the chemical action begins. This time—from the wetting of the cement to the disappearance of the moisture from the surface—shows how long may be occupied in working and placing the

cement in its final position in the work. When a cement has begun to set it should not be disturbed, because interrupting the chemical action destroys in whole or in part the effect of that action and the cement will lose half if not all its coherence.

Though the selection of a proper cement is of paramount importance in making a good mortar or concrete, still neglect and carelessness in the selection of the other materials and in their preparation will result in inferior work, if not fatally. We are all familiar with the trite specification "clean, sharp, sand," but even if this were always complied with it would not necessarily insure the best mortar or concrete. In the case of lime mortar the binding properties appear to be due solely to the hardening and cementation, while in cement mortar and concrete made of a silicious sand and aggregate, there appear to be a chemical combination between the cement and other ingredients. The bond between good cement mortar and a stone of silicious composition is rarely, if ever, broken; the break invariably being in the body of the mortar. However, when an aggregate of a calcarious compostion is used the binding properties of cement are similar to those of lime, except of course, being much stronger. This has been demonstrated in practical work many times, and Mr. E. J. De Smedt (at one time chemist for the district of Columbia and inspector general of ashphalt and cement), after investigating the subject reported substantially the same thing. In his report for 1886 he says, "Silica and silicates have a great affinity for hydraulic cements and produce great adhesive power, while carbonates such as carbonate of lime, etc., have much less and give poor results. In a clear washed sand containing twenty per cent carbonacious sand used with hydraulic cement the tensile strength was reduced thirty per cent. After having been treated with hydrochloric acid and washed in order to remove the carbonate from the sand, its initial adhesive power was restored." The engineer commissioners of the District of Columbia have the facilities and have been making an exhaustive investigation in regard to the best material to be used with

cement, a report of which has not yet been published, however. From the report of Mr. De Smedt and from many practical examples it is evident there is no advantage in using broken stone and that it is a mistake to specify only broken stone, especially when it is limestone, and a silicious gravel may be had cheaper. Furthermore, many engineers prefer to use round gravel stones alone or mixed with broken stones for other reasons, and contend that gravel alone or gravel mixed with broken stone prevents any tendency to arching, and hence makes a more homogeneous mass. Again gravel or the mixture will pack more closely and require less mortar and yet be stronger. In selecting ingredients to be used with cement only those of a silicious nature should be used to obtain the best results. A sand of a calcareous composition will be readily distinguished if, when immersed in weak hydrochloric acid an effervescence appears.

The statement is often made that cement mixed with one, two, three or four parts of sand is three-quarters, one-half, one-third and one-fourth, respectively, as strong as clear cement. Though this statement is by no means proven by experiment still it is clear enough for most purposes.

To obtain the best results cement and sand should be so proportioned that the volume of cement will slightly exceed the volume of voids in the sand. In most cases this condition is filled by the proportions of one cement to two sand, as the voids in sand are often about thirty per cent. Where large quantities of mortar are to be used, however, the voids should be determined and the proportions made accordingly. The same principle applies in regard to the making of concrete, i. e., the volume of matrix should slightly exceed the voids in the aggregate. The voids of gravel and broken stone or the two mixed are much more variable than in sand, and so should be determined from time to time during the progress of the work. Occasionally the proportions of matrix to aggregate will be one to four, but it is usually specified one to two, or one to two and one-half. The voids in sand and gravel may be

measured by filling a known volume with the material, then noting the amount of water that can be added. In cement mortar a coarse sand is preferable to a fine one, and in concrete it is usually specified that no dimension of the stones shall be longer than two, or two and one-half inches. Some engineers limit the size to one inch.

In mass concrete it is often economical to inbed large stones. This is objected to by many because the mass is thus rendered unhomogeneous and unreliable. However, few, if any, ill effects have resulted from the practice. It is important that these large stones be well bedded and the concrete mortar carefully packed around them.

If the materials selected are not properly worked, even though they be the best, poor and unreliable concrete will result. Many of the failures of concrete construction reported are directly traceable to neglect in the mixing of ingredients. A mortar composed of one cement and three sand thoroughly worked is far better than one composed of half and half and insufficiently worked. Too much care cannot be given to the mixing. The sand and cement should first be mixed dry, when the aggregate and the water may be added and the mass again worked. Each particle of sand should be coated with cement and each stone coated with mortar. When the cement is spread over the sand in the ordinary mortar box it will require at least three complete turnings of the mass to properly mix. There are machines made that are more reliable and cheaper than hand mixing. The amount of water to be used varies and is best judged from experience; though the mass must be well wet, still it must be stiff. When the mortar is mixed with water, before the stones are added, they should be wet so as not to absorb the water from the mortar.

It is safest to mix only such an amount of concrete as can be placed immediately in the work and to place it as soon as mixed. Concrete should not be allowed to fall from a height under the supposition that it will thus pack sufficiently, because in falling the stones and mortar will separate, the

stones going to the bottom, and instead of having a homogeneous mass there will be a layer of stones and a layer of mortar. It should be placed carefully, in layers of six to eight inches, and well tamped until moisture appears on the surface, indicating the mass has been well compacted. It will require some little experience in mixing to use just enough water to obtain this result with moderately hard tamping.

There are several methods employed for depositing concrete under water, the most satisfactory being to use bags of paper or coarse cloth; the paper is soon destroyed by water, and the cloth bags may be laid so as to bond and the cement oozing through makes a fast joint. In running water a quick setting cement is to be preferred.

A very prevalent notion is that cement should not be used in cold weather; there is no foundation for such an opinion. It has been proved many times that concrete, made even in freezing weather, is sound and reliable. True, the induration is very much retarded, but the final strength seems to be unaffected. Many engineers advocate the use of salt water in cold weather, and no doubt this is advantageous.

When it is necessary to join "green concrete" to that which has set, the surface of the old should be roughened, brushed clean and well smeared with a paste of clear cement mortar just before placing the new concrete. There need be no fear of joints thus made. Ordinarily simply cleaning and smearing the surface of the old concrete is sufficient. If it is desired to make a joint that may be separated at some future time, a thin layer of sand will do it.

When the surface of concrete is exposed to wear or view, a facing of mortar is used, which may be molded into very ornamental figures. In most cases the object is to obtain a better wearing surface and a dense coating, to more surely prevent the absorption of water, as in bridge piers and sidewalks. This facing is composed of one volume cement to one or two volumes of sand, and is placed in the form just ahead of the concrete and tamped with and into it, thus making an irregu-

larly defined joint. Bridge piers protected in this way have withstood for ten years the shocks from the heaviest ice flows and log jams in Nova Scotia and show no signs of failure yet. When this facing is well dressed with a trowel, as in sidewalks, a hard, dense skin is formed which is very resistent to all kinds of wear. The thickness of this facing varies from about one inch, in sidewalks, to eighteen or twenty-four inches in some bridge piers. In this connection it is important to know the abrasive resistance of cement mixed with differ ent proportions of sand. But few experiments in this regard have been made in this country. In Germany they have a method of grinding briquettes and by weight determining the loss resulting from the abrasion. Mr. Max Gary, a German engineer, gives table number four, in which it is seen that a mortar composed of one cement and one or two sand is the most resistant. It is said that tests made in connection with the Niagara Power Station to determine the abrasive effect of flowing water gave practically the same result.

Table Four.

Proportions of cement and sand	1;0	1;1	1;2	1;3	1;4	1;5
Comparative loss	4.7	1.7	1.9	3.6	5.9	13.8

In hot, dry weather concrete should be protected and kept constantly moist for two or three days to prevent the evaporation of water before the cement has thoroughly set.

The cost of concrete is so dependent on local conditions and its proportions that a statement in this regard would be misleading. In most localities, however, the best Portland cement concrete in mass will cost about $8 or less per cubic yard, and Natural cement concrete $6 or less.

One of the first and most general objections raised to concrete is that "it will not stand the climate." Exactly what is meant by this I do not know, but concrete structures have stood for years in all ranges of climate from the equator to the north of Nova Scotia, exposed to both the action of air and water. Nova Scotia not only has a wide range of temperature

—ordinarily fifteen below to ninety above zero Fahrenheit—but it has what is still more severe on masonry, very sudden and great changes, for instance: A drop of forty degrees in twelve hours. There the best natural stone piers have failed in a few years and been successfully replaced by concrete, and in one instance a facing of fine concrete has been used to protect a masonry pier that was fast disintegrating. Mr. Martin Murphy, government engineer of Nova Scotia, after more than ten years experience with concrete, said in his paper before the International Engineering Congress in 1893, that concrete was first used by him in 1883 as a susbtitute for masonry in bridges, "at first sparingly and with hesitation, but of late it has been used largely and with much confidence." It is said water will be absorbed by concrete, freeze and thus disintegrate it, but experience proves that with properly made Portland cement concrete such is not the case. It is also objected that concrete will fail by contraction and expansion, but there is no more liability to failure from this cause than in any other class of masonry; and in all structures so situated as to be liable to excessive temperature stresses provision should be made to withstand them.

F. von Emperger of New York states that Bonnioeau, a Frenchman, gives the expansion of concrete as .0000143 for one degree centigrade, which is practically the same as that of iron and steel. I believe it is now generally admitted that concrete and iron have practically the same co-efficient of expansion. This fact should be remembered when it is recalled that the use of iron and concrete in combination is becoming so general and is being advocated by prominent engineers. Concrete is one of the best conservators of iron known, pieces imbedded in blocks of concrete, exposed to all weather for years, having remained perfectly rust free, while the part of the same iron not imbedded has rusted entirely away.

Compression tests of cement, mortar and concrete made by the United States board for testing materials in 1884 developed

the somewhat unexpected fact that concrete was as strong or stronger than clear mortar in compression.

Table four gives the ultimate resistance to crushing of several different proportions of mortar and concrete. Unfortunately the tensile strength of the cement used cannot be given, and the table is of little importance.

Table Five.—Compressive strength of differently proportioned mortars and concretes.

	Per sq. in.
PORTLAND.	
Clear cement	6,000
1 cement, 3 sand	2,700
1 cement, 3 sand, 6 broken stone	3,060
1 cement, 2 sand, 3 pebbles, 4 broken stone (6 mos. old)	2,000
NATURAL.	
1 cement, 1½ sand	1,550
1 cement, 3 sand	850
1 cement, 1½ sand, 6 broken stone	1,550
1 cement, 3 sand, 6 broken stone	1,025
1 cement, 3 sand, 2 gravel, 4 broken stone	1,080
1 cement, 1 sand, 4 broken limestone	1,200
1 cement, 2 sand, 4 broken limestone	940

Mr. Ernest L. Ransom gives an empirical formula for the crushing strength of concrete, which he says "is reasonably correct and quite safe to act upon." The crushing strength in tons per square foot one month old, equals 700 multiplied by the ratio of cement to aggregate.

A = Proportion of cement.

B = Proportion of aggregate.

Crushing strength in tons per square foot $= \frac{700 \times A}{B}$

The final strength will be 50% greater.

This paper has been prepared with a view to introducing the subject, and it is hoped it will be followed by discussion, and future papers treating the subject more in detail.

THE PRESIDENT: That paper is a very valuable summary of the facts established in regard to the action of mortar and concrete, as valuable as I have ever seen embodied, and it shows very careful study.

There are two points in regard to which I have often had my doubts. One is, whether the cement mortar is affected badly by frosts. My own impression has always been that it is, and in putting up some concrete structures during the last winter, I used every precaution I could think of. I put salt in the water, and used hot water and had the sand and rock heated, and still it seemed to me that the frost did injure that cement.

MR. APPLETON: Do you know that the frosts injured it?

COL. MUENSCHER: I know we examined that concrete some weeks afterward, and it seemed to be just a loose mass of stone and sand.

Q. What kind of weather were you getting at the time?

A. We had some very cold snaps.

MR. RANDALL: My experience with that material has been that in working it, where the nights are cold and frosty, with comparatively warm days, freezing and thawing before the mortar in the mixture has attained a good set, it is very liable to destroy the concrete.

But I have used considerable concrete in very cold weather, and my impression is, that hydraulic cement in any form, is not injured by being used in cold weather, so long as the weather remains cold, and if there is no thawing until after the concrete has attained a good set.

COL. MUENSCHER: The case I mentioned was a large steel cylinder, 22 feet in diameter, filled with concrete, and this concrete was made on shore and run over in boxes and deposited. The weather was considerably below freezing all the time, and it never got a chance to thaw. In fact, it didn't get any chance to thaw until spring opened.

MR. APPLETON: Did it freeze dry?

COL. MUENSCHER: It froze hard. The water in the mortar became ice, and was lost in it—became homogeneous.

MR. APPLETON: Have you examined the mass since it was put in?

COL. MUENSCHER: Yes; it gave rise to a great controversy

there. The contractor was kept out of his money several months on the plea that the concrete was bad, and finally in order to test the matter, we cut a piece out of the cylinder large enough to get a sharp pointed piece of iron in, and they took out a part of that concrete, and it was just a mass of loose stone and sand. But, we find now, after a season has passed by, that same stuff that acted like a mass of loose stone and sand, is becoming solid and hard.

MR. RANDALL: Then it is good?

COL. MUENSCHER: It has had an opportunity to dry out, and it is now becoming hard and solid.

MR. RANDALL: I have always looked with suspicion upon work done in cold weather, and I think it is founded on good reasons. The freezing locks the water in the form of ice crystals, and the concrete has no more chance to set than if so many glass beads had been mixed with it, instead of water.

MR. SEARS: It is important that we make an application of these facts, if true. I watched some men laying concrete foundations for paving last year. I saw them break up lumps half as big as that box. In emptying a sack, they would take it all and crush it up and pulverize it. Is that the proper thing to do? We think we are going to get a perfect foundation if we use cement, and I would like to ask Mr. Hillyer, which he would recommend, a natural or a Portland cement, for making a foundation for pavements.

MR. HILLYER: It is a question of expense. For a street foundation, the natural cement would make a sufficiently strong pavement. Lumps should not be broken up and used, but should be thrown out entirely. When cement full of lumps is being used, the contractor is getting the best of the buyer.

MR. SEARS: Each one of these makers says he has the best cement in the world.

MR. HILLYER: Perhaps it was all right at first, but it must have been moistened to lump that way.

MR. SEARS: In the construction of bridge masonry, I

commenced using the Milwaukee cement. I mixed one part cement to 1½ of sand, and the result was not satisfactory. I then tried Norton's American Portland, at $1.50 per barrel; that gave better satisfaction. I then tried Portland and that was better still. It is a little more expensive, but in my opinion it is the best of all. I think it will make a better concrete, mixed three to four parts of sand, than the others two to four of sand. That paper brings out one point to me that is valuable—that gravel is better than broken stone.

MR. WILLIAMS: A point occurs to me, in connection with this bridge pier, possibly explaining the action there. As was discovered a good while ago, any cement, whatever its condition, if it is excluded from the air, is very slow in setting, and the fact that the temperature was low at the time the cement was put in, retarded its setting. After the layer was covered, and it was excluded from the air, its setting would certainly be very slow, and the fact that after this opening was made, the stone set, looks to me very much as though the real cause of the trouble was that too much was put in at a time.

COL. MUENSCHER: Would you understand, then, that if we had put that in, in layers of moderate thickness, and let it freeze, and lie in that condition, do you understand that it would have set any better? Do you think concrete can set after it has frozen?

MR. WILLIAMS: Yes; but in using concrete in a place of that kind, I think it would be very doubtful if you could be successful in using it in cold weather. You can lay concrete in moderately cold weather, but when you come to put it in a large mass, and enclose it, I think there is danger of its not setting, and as the material did not have an opportunity to begin to set as it was going in, there was small chance of its setting for a long time afterward.

You know in European countries, mortar has been found in the center of large sewers in very old buildings that had been there for centuries, that has been in a comparatively green

condition, and it seems as if we had the ideal conditions in this bridge pier for this same thing.

I believe that Rankin advocates, in heavy masonry, leaving an opening between the stones, and the same would apply to concrete I should think.

There was another point I was going to bring up, bearing in in a different direction, regarding an experience we had in Detroit.

The public lighting commission, during the year 1898, constructed a number of man holes about town, in which the concrete was used for the bottom; it became necessary to make some changes (the cement used, I believe, was the Milwaukee).

On those which were dry, they mixed the cement in the ordinary way, and rammed it until the moisture came to the surface. In some of them, however, the ground was so wet it was necessary to use pumps, and the concrete was mixed up as wet as possible and poured in—sand, gravel and all.

During this past season, they have had occasion to break out some of both sorts, and as near as they can see there was no difference in the quality of the concrete.

Of course that is not a common thing, and yet an engineer watching his men carefully would be able to judge pretty accurately whether he was getting as good concrete in one instance as another. The gentleman under whose direction this work was done is one in whom I have a good deal of confidence.

MR. RANDALL: It is a new idea to me that concrete needs air in order to make it set. We all know that ordinary lime mortar requires air in order to set—that it will never set without. The lime, C_aO, requires carbonic acid to make the carbonate. It has to have this exposure to the air, and also to the moisture to carry the carbonic acid to the lime. Most cements are not carbonates but silicates, and although the air may play some part in setting, I never supposed it did.

COL. MUENSCHER: Another point, the system of testing cement, that has gradually grown up in this country, has

become so complex that nine engineers out of ten cannot use it at all. It is necessary to have expensive machinery, which our small cities will not buy, and most of the railroads will not buy. The engineer cannot afford to buy it himself, and even if he has the machinery it is necessary to have a large amount of experience in order to conduct the tests in such a way that they are at all reliable. The least variation in the pressure on the briquettes ruins the experiment—causes the briquettes to break in such a way that it is really no test at all.

What the average engineer wants is a more simple system of testing. I was pleased a year ago to see a paper, a graduating theme of two young men in the engineering school, the subject of which was the testing of cements. They adopted the system of making a rectangular block of small size, and testing it simply by a cross strain, a weight in the middle with the ends resting on bearings. Now if we could perfect a system of testing like that it seems to me, it would be just what the average engineer wants—something that he can apply without any very complicated machinery or any great amount of experience. When you come down to the present system, and have got to mix your cement just in a particular way, with a certain number of ounces of water and cement, and press it into the mold with so many pounds pressure to the square inch, and have got to measure the size of the grains of sand with a magnifying glass (or your experiments are of no use), the average engineer cannot do anything with it. He must have a simpler method, or go without testing. I do all my testing with my fingers. I test the cement by feeling of it with the fingers. As a general rule, I think I get it about as nearly right as with a complicated set of machines.

MR. RANDALL: Where cement is laid in a dry place, I don't think it always gets water enough in setting.

You may put enough water with cement, when you first put the water in, to make it work right, but in a short time the water will disappear, and if you don't put in more water there

will not be enough moisture to complete this chemical change we call setting.

MR. SEARS: I think the gentleman is right in that, and that a mistake is made on half the work in paving, and that the street foundation often has very little value. They mix that concrete on platforms in a hot sun—just moist enough to manipulate. I have gone along myself, and dug with my heel —worked right down into it, after three or four days. And that is a good point—it should be kept wet.

I saw some buildings going up in Saginaw in cold weather. I said to the workmen, "You will have a failure here." But it is the best piece of masonry in that town.

COL. MUENSCHER: I want to know if I have been mistaken in accepting the theory that frost will destroy the quality of cement.

MR. APPLETON: Freezing and thawing will hurt it.

MR. BLAIR: I had a little experience in December in building two catch basins. The contractor was a little behind with his work and wanted to get it finished up and he used Portland cement. It was very cold weather. I had to keep a boiler of water hot, in which I soaked the brick. The mason hated to use it and his mortar was made pretty stout with cement, and built up with sand. We used a large quantity of cement on the catch basins, but they were this summer two of the best we had in Adrian. The bricks were soaked in hot water and put in hot.

COL. MUENSCHER: It used to be the rule in government specifications, that no work in masonry should be done after the first of November. I guess we will have to change that, and provide that none shall be done before the first of November.

MR. SEARS: I have seen building going on way below zero in St. Paul.

MR. HILLYER: In regard to this heating of materials before putting them in the work, Mr. Wm. McKay, who was engineer for the department of docks, New York, made extensive tests

in regard to the advisability of doing that. Altogether between seven and ten thousand tests were made, of just such practical questions, and among others was that of the heating of the materials before mixing them, and then allowing them to set in cold weather, which was found to be injurious. If you heated them and kept them warm, it was all right, but to heat them and put them in the cold was injurious. Another thing he brought out was the bad effect of variation in temperature —freezing and thawing. Briquettes that were made with hot water and placed in the cold, or kept in a room in which the temperature was variable, were very much weakened.

I believe nine-tenths of all the poor concrete is due to the inefficient mixing. You will notice it in any work you come upon in the street, whether the inspector is there or not, in the making of sidewalks. They will throw the sand and cement on the platform, throw in the stone and water, and shovel it in. That is all there is to it, no mixing at all.

SOME DIFFICULTIES IN MANUFACTURING.

CLARENCE E. BEMENT.

This paper might be more appropriately named "One Manufacturer's Difficulties in Manufacturing," as the writer's sixteen years' connection with the manufacturing business has been in one capacity, in one institution, and in one limited line of manufacturing, and he has no call to speak for any but his own institution, only as he supposes that his experience has been the general experience of others.

These are days in which complete manufacturing plants are erected, supplied with every device which money (which means mechanical skill) can supply to facilitate and cheapen work. Our plant, much to our regret, did not spring goddess-like into perfect being at one stroke, but has been the result of twenty-five years of accretions, and thereby hangs this tale, for from this source has arisen many of our difficulties.

One of the most serious problems is that involved in the transmission of power. When our work was performed by a portable saw-mill boiler and engine, and about fifty feet of one and fifteen-sixteenths shafting, it presented few difficulties, but with two hundred and fifty horse-power to transmit, and two thousand feet of line shafting, varying from 3 15-16 to 1 15-16, and with no two of our buildings on the same level, the problem becomes more complicated. We have adopted a few general principles with regard to shafting and pulleys. All shafting is one of three sizes—1 15-16, 2 7-16 and 2 15-16—and every piece bought within the last six years is twelve feet long. All couplings are drilled to one templet for corresponding sizes of shafting, so that we have little trouble in replacing a broken piece. All plain pulleys bought within the last five years are those made by the Medart Wrought Iron Pulley Co., and all of them over twelve inches in diameter are split. Those

bought with 1 15-16 hole have hubs large enough to stand boring to 2 7-16. Those bought with 2 7-16 hole have hubs large enough to stand boring to 2 15-16. This is done to enable us to increase the size of shafting as the number of machines attached to it demands, and use the same pulleys. The grade of the street on which our works are located has been raised two or three feet since the first buildings were erected, so that in building a new wood shop some four years ago we were obliged to raise it some three feet above the level of one of the old main buildings in which our power and main line shaft were located. The line shaft could not be continued, and the line shaft in the new building was only three feet above the old one, not giving sufficient length of belt to drive one from the other. By a very simple arrangement of idler pulleys and frame, devised by Mr. S. E. Jarvis, the power necessary to run all our wood working machines is transmitted by a 14-inch belt, giving as great efficiency as though the shafts were twenty feet apart.

Power is furnished to our blacksmith and forge department, which is at right angles to the other buildings, by an independent engine, and steam from the main boiler house. There are reasons why this method, though it may not represent the highest theoretical economy, is the most economical for our purposes. In the first place, the work done by this department is used by the wood and machine shops, and consequently it is more frequently behind in its work and oftener needs to run over time. With the present arrangement this can be done without running the main engine and a long line of intervening shafting. So, too, if anything happens to the main engine the forge department is not obliged to shut down.

The economy of a similar arrangement in the foundry is not so apparent, but it has enabled us to take off several heats in the last five or six years when the main engine was disabled. It also enables us to vary the speed of the fan during the heat, either to increase or slacken, or increase or diminish the speed with which the iron is being melted.

The question of counter-shafts in a manufacturing institution is always a vexed one, and I am not very confident that our experiment is a solution. In equipping a new stove shop three years ago we tried the experiment of substituting for about thirty countershafts an equal number of clutch pulleys. We certainly have not spent as much money for repairs by this arrangement, and have saved considerable machinery and belting. That the experiment was not a distinct success arose more from the fact that we made a mistake in the selection of the clutch pulley than from any failure of the scheme itself. This experience has not deterred us, however, from the use of clutch pulleys in making connections from the main line shaft to shorter pieces of shafting in the same or other departments, thereby enabling us to shut down one line or department without stopping the whole shop.

As before stated, the enlargement of a plant beyond the capacity originally designed, always presents many unforeseen difficulties, especially in the matter of light and convenience in handling material. Our forge department, built some twelve years ago, was at first 50x100 feet, and was considered ample to do our business for at least twenty-five years. But we added first 75 feet to its length, then 30x175 feet on one side, then 70x80 feet to its length again, giving us a building 250x80, with two or three inside walls pierced by arched openings, and with a roof made up of half a dozen pitches and gables. The light was bad, the ventilation worse, and it was as expensive a shop to handle material in as you can imagine. In remodeling this building a year ago, after a fire which destroyed the roof, we were enabled to get it into very good shape by raising the side walls to 17 feet, carrying the roof on two rows of heavy posts, and making it practically fire proof by using No. 20 corrugated steel, resting on heavy timber purlins five feet apart, thus getting rid of all wood except enough to support the middle and ends of the 10 foot sheets of corrugated steel. We also substituted for the ventilator which we have been in the habit of using on this class of

buildings, flat windows at the peak, end to end, and opening by sliding in grooves down the roof. We thus avoid the danger of fire arising from the ordinary ventilator, which had been the cause of our two most serious conflagrations. In this building, too, we attached our shafting to posts instead of hanging it to the roof or ceiling as heretofore, thus obtaining greater solidity and avoiding the eternal getting-out-of-line that goes with shafting hung from roof or ceiling.

In the foundry about the same condition exists as in the forge department. It runs straggling along the river's bank for 450 feet, and is made up of three additions and the main building, all at different angles to each other. As our cupola is not in the center of this 450 feet, we have been in the habit of furnishing the extreme end with iron by means of big bull ladles, carried by two, three or four men; this required about ten men for a portion of every heat, in addition to the moulders who used the iron. At the time of putting on the last addition, we decided that it would be necessary to provide some more economical method of transporting this iron, as well as for handling the casting from the "mash" to the cleaning room. Mr. S. E. Jarvis, of this city, designed an overhead track that has enabled us to dispense with six of the ten men for handling the iron, and cut down our force of cupola men, tenders, casting cleaners, etc., from an average of thirty to an average of twenty-five, while the amount of iron we melt per diem has increased from an average of 15 tons to an average of 20 tons per diem. Mr. Jarvis' track consists of a plain 6-inch "I" beam, weighing fifteen pounds, laid flat wise and suspended by hangers attached to the web. The traveler consists of two pulleys attached to the two angles of an equilateral triangle, the pulleys running on the edge of the flange of the "I" beam, and the load suspended from the third angle of the triangle. As the cleaning room is in another building, and across a railroad track, and the cupola at one side of the center line of the molding room, it was necessary to provide a system of switches, and a broken section of track,

all of which was easily accomplished through Mr. Jarvis' well known ingenuity.

The worst feature in adding to an old plant is the necessity of cutting off the light on some side. The average manufacturing building is built without light enough, especially if it is more than one story high, and when you begin by putting an addition, first on one side and then another, you eventually get a shop without any light, and this has been our experience. The only remedy, now, is plenty of artificial light, and this we have tried to supply by means of electricity, but even that is a poor substitute for daylight.

Another harassing question is that of keeping up repairs on machinery and tools, and in spite of every effort this item crawls up on you. You may start in with a modest repair shop outfit of a second hand lathe and planer and two men to run them, but it does not take long for that force to crawl up to five or six or even eight men, and the inventory of your repair shop to represent three or four thousand dollars, instead of the five hundred you started with. We do not realize what a difference exists between working a machine up to its capacity, and only doing a moderate amount of work on it until you have consulted the repair shop's account with that machine in the dull season and the busy season. You ordinarily run ten hours out of the twenty-four, but in the busy season, from December 1 to March 1, you may run twenty-two hours out of the twenty-four, and then apparently the work of the repair department does not double, but it trebles, and you have a broken machine on your hands for a steady diet. This of course may arise from the fact that night forces are generally picked up, not from the best class of workmen, but from those who are out of work. In order to avoid complications in repairs we have adopted the plan, when possible, of buying all of one class of machines of one make and also one size, when that is feasible. This simplifies carrying repairs in stock. So, too, it saves expense in patterns, as we always intend when a machine breaks down to make the repairs ourselves, and con-

sequently the making of one pattern, if it is a cast piece, may repair several machines. Small machines, like emery grinders and buffers, are made in our repair shop to standard sizes, and as the shaft is what wears out in these machines, we only have to have one in stock to repair any machine of that size. When a piece has proven weak it is then put into stock and one or more extras always carried.

A manufacturing plant making one article, or a limited variety of one class of articles, has little knowledge of the additional labor involved in the manufacture of a large and varied class of goods. In these days manufacturing is not one business to be learned, but every one of its different branches is a business of itself. You may know a good deal about forming flat steel plates into shape under a drop hammer and be absolutely ignorant of the methods of making drop forgings, or even of forming your own steel plates in deep shapes under a drawing press. So that it happens that building a new tool or article, may involve, and quite often does, learning a new trade.

Every new tool also involves the addition to the plant of just so many square feet of floor space, and this in every department aside from the warehouse where surplus stock, or stock for future shipment is kept. Suppose the new tool has twenty-five or one hundred different pieces, and the latter is the safer figure, and you are going to make a thousand of the articles. Every one of these pieces must have room as it passes through the department in which it originates, to the department in which the tool is assembled. As it is physically impossible, ordinarily, to get all parts of a tool together at just the same time, there must be in the assembling room, racks, or bins, or barrels, or other means of storing these parts while the rest are coming through, and here comes one of the greatest difficulties in manufacturing a great variety of tools, viz., that no tool can be mounted or assembled as long as there is missing one bolt, or nut, or washer, or cotter, or the slightest and most insignificant piece that goes to the making of that

tool. The 1 in. x 9-64 spring cotter is just as essential as the 25 pound piece of casting or the 50 pound steel frame, or the 4 foot wheel.

No problem worries the average superintendent more than the management of the men. As a plant increases in size, and more men are employed, one loses his personal grip on the employes, and is more frequently tempted to deal with them as a body, and not take personal peculiarities and conditions into account. This on the part of the employer leads to lack of sympathy, and the laying down of arbitrary rules that do not always work to the advantage of the men, and on the part of the men to a spirit of not "caring a damn," that is most injurious to the employer. A spirit of accommodation must be cultivated, and no superintendent should ever decide a question with relation to his men while angry. In my judgment more labor troubles arise from both sides going off at half-cock than from any other cause. Small personal accommodations to men I have found of the greatest value in tying them to one's interest, and making them feel that your good and prosperty was theirs. But in this connection the foreman becomes of great importance, as well in that as in the direct manufacturing. A superintendent's grief in connection with the handling of men generally comes from those departments whose foremen lack judgment and good common sense. The foremen are the most important elements in good and economical manufacturing. It is very easy to define a good foreman, but not so easy to find him. He must, to crown all, be systematic; then be able to get along with men and know when they are doing a day's work and how to make them do it. He must have firmness, determination and nerve, and ought to be a first-class mechanic in his line.

In these days of piece work there has arisen a new difficulty in manufacturing. It is called nursing a job, and consists in doing only as much of a day's work as will make fair wages and not lead to a cut. The man arguing that if he makes $2.50 per diem on his machine,

his piece price will not be disturbed, while if he makes $3.50 per diem, which he can easily do, it will simply result in his wages being cut to a basis of $2.50 and making him work so much harder. This system of nursing jobs exists in every shop where piece work is being done, and especially where a number of machines are doing the same class of work, and you are largely dependent upon the sagacity of the foreman to discover and remedy the trouble. It sometimes necessitates the changing of the entire force. Another draw back to piece work is the education of the men to think that it is worth more to do the same thing by the piece than by the day. For example, a man might turn out a hundred pieces of a certain kind for a day's work, for which he would be satisfied if he received a $1.50 per day, but if you wanted him to work by the piece he would expect to receive $2.00 for the same amount of labor. In other words, the men look upon piece work as a sort of fetich which the employer is willing to pay something for worshipping.

I have consumed enough of your time in relating what are simply my personal experiences, but in closing wish to speak of one of the greatest drawbacks in the manufacturing business in at least one institution that I know of, viz., the lack of technical education on the part of the employers, or the superintendent, at least. I am a hearty believer in *practical* knowledge, and see its necessity more every day. But if to one's practical experience can be added the best technical education, who can dispute the excellence that would result. The only trouble is that technical education gives some men an exaggerated condition of big-head so that they do not properly profit by their practical experience. If there could be some arrangement made by which men could first get their practical experience and then add to it the technical education, it would, it seems to me, be an ideal state of affairs.

MR. WILLIAMS: Being a man with a technical education myself, I thank Mr. Bement for his words on that line. We technical fellows are often ruled out of court by those who are

less so, and I am glad to see a man of his standing who admits that a technical education may be worth having. I appreciate the point he makes about mixing the technical and practical, and I think those courses in our universities working along that line are leading to the best results we are getting today.

MR. APPLETON: I would like to ask Mr. Bement which system he finds works best on the whole, the piece work or the day work system. He says the men want piece work. I would ask him if he doesn't think that the most satisfactory way for manufacturers?

MR. BEMENT: I have always been an advocate for piece work, but I have made up my mind that piece work is not an unmixed blessing either, to an employer or an employe. In the first place it makes men work too hard. There is no question in my mind but what a great many men kill themselves overworking. I believe they do it in our institution. Of course a man gets paid for what he is able to do. The particularly smart fellow gets well paid, but the tendency of the employer is, if a man gets so he makes $4.00 or $5.00 a day, having started in at say $1.25, we think we ought to have a portion of that advance. It is done in every shop I know anything about. When a man develops unusual skill, you are willing to pay him a good big price, but not on the basis he started out. We are entitled to some of the benefit arising from the increased capacity, but the fact is, it does get men to working too hard, and then it leads to this other spirit of hypocrisy, what we call nursing a job, where men simply sit back and don't propose to do a day's work, and the fact is we are doing more day work than a year ago.

Q. Don't you find trouble with soldiering?

MR. BEMENT: Yes; but you must depend upon your foreman.

MR. WILLIAMS: Have you been able to arrange anything in the way of a stint—that a man must do a certain amount?

MR. BEMENT: We have a system by which every man's days work is on record. We know what every man does, but we depend on the foreman. Of course no superintendent or

assistant superintendent, where five hundred men are employed, can keep track of what they are doing; you must depend on the foreman largely. Of course the advantage of the piece work is, you know exactly what things cost, you are not guessing at all.

OLD SURVEYS OF DETROIT AND VICINITY.

THOMAS CAMPAU.

To the Michigan Engineering Society:

GENTLEMEN—Through the medium of your worthy secretary, I was requested to prepare a paper on the "Old Surveys of Detroit and vicinity," as contribution to your annual meeting to be held during the third week in January, 1895. I very reluctantly promised to do so, for I felt that I was not competent to do the subject matter the justice which it deserves; however, I determined to do the best I could.

By the way, it brought to my mind a certain temperance meeting we had fifty odd years ago. The principal speakers failed to put in an appearance at the appointed hour; there was an old enthusiastic fellow, who wished to hear some talking, he did not know what to say himself, but nevertheless he mustered up courage enough to rise, and, addressing the audience, said, "Get up some of you and talk, say something. In whatever you say there may possibly be some good words among all the nonsense and foolishness which you say." So it is with me. Among the nonsense I may say to you, there may possibly be a few good words, but I actually believe a very few, if any.

Detroit is an old French settlement, which dates back to 1701, so history tells us. "Les Habitants" (the settlers) or part of them, acquired titles to their lands or farms from their government, some perhaps from the Indians. These lands, or private claims, as they are now called, were laid out very regularly, so much so that they must have been laid out by some surveyor, the records of whom do not seem to be in existence at the present day. The farms or private claims front on the River Detroit and Lake St. Claire. There are also other claims, which front on the River Rouge and other small rivers

or creeks that were acquired subsequently. The claims were originally laid out from two to six arpents in width, but were mostly three arpents wide by forty arpents in depth. As there may possibly be some among you who have not had the need or occasion to make use of this measure, "the arpent," I will tell you what an arpent is and to what use and purpose it was employed.

The arpent or French acre was employed as a lineal as well as a square measure. It is composed of 180 French feet, "Pied du Roi" (King's foot). The mode of measuring was with a pole of 18 (French) feet, 10 poles making an arpent. The proportion which the French foot bears to the English foot is as 1,000 is to 1,068. The aprent is used by the descendants of the old settlers to this day, and it is used by them in the same manner as we use rods. For instance, in estimating any distance whatever, we generally say it is "so many rods;" they say it is "so many arpents," although they know what the length of a rod is; still they do not seem to have any definite idea in their minds of its magnitude, but when one talks "arpents" to them, they are perfectly at home.

The arpent varies in length in different localities, as will be seen by the exhaustive researches made by the commissioners on private land claims, appointed by the United States government to settle the title to the rightful owners of these claims. After carefully examining the subject, the commissioners arrived at the conclusion that the arpent used in the vicinity of Detroit is $192\frac{24}{100}$ English feet. Any one desiring to examine the procedures of the commissioners in the matter will find the same in volume 1 (or 16) at page 264, "American State Papers." The commissioners, after completing the work for which they had been appointed, reported their proceedings to congress, which report was adopted and became law.

Tradition says that the first surveys at Detroit were made by Navarre. In looking through my grandfather's papers, my father found a paper which refers to the measurements of these

ancient land claims, which to my mind throws a little light on the subject and reads as follows:

J'ai parfaite connaissance d'avoir mésuré ily a longtems les terres concédées aux habitants au Detroit, mais leur ayans laissé le soins de se conserver leur bornes mitoyenne. Je ne puis aujourd' huit reconnaitre les points ou out eté plantées les bornes, parcequ'elles out eté ou derangées par les eaux ou par les travaux des fsset qu'on a fait sur les bornes memes, ces fossets servant de separations aux habitants, c'est sur ces bornages que les habitants ont établi leurs clotures et des fossets de separation dont ils etaient contents alors, puisqu'il subsistent encore aujourd'hui.

Fait au Detroit le 2e May 1764.

NAVARRE.

The above is written in very good French, with the exception of the orthography of a few words, which slightly differ from the modern style. The following is a literal translation of the foregoing paper, to wit:

"I have a perfect recollection of measuring long time ago, the lands conceded to the settlers at Detroit, but, having entrusted them with the care of preserving their dividing boundaries, I cannot at the present time identify the points where said boundaries were established, because they have been displaced either by the flow of the water or by working of the ditches which were made on the very boundaries; those ditches serving as dividing lines to the settlers. It is on those boundaries that the settlers have built their fences and line ditches, of which they were then satisfied, since they remain at the present time.

Made at Detroit May 2d, 1764.

NAVARRE.

This paper seems to confirm tradition, that Navarre was about the first surveyor that surveyed in the vicinity of Detroit. We find at the present day traces of the ditches he mentions in his paper, and they have frequently been of great

help to me in retracing the lines of these old claims which I have been called upon to do many times.

Mr. Greeley, of whom I will speak later on, undoubtedly recognized those ditches as the dividing lines of the claims, for I find his surveys agree remarkably well with them.

In 1763, the dominion of the French over the country passed to the British government. Under this last government, I am not aware that surveys of any importance were accomplished in this locality.

In 1796 the territory passed from the British to the United States. In the treaty between the French and the British, so also between the British and the United States government, it was formally stipulated that the settlers should not be disturbed in their possessions; which stipulation was strictly respected and lived up to.

In 1807, in order to give the settlers in this locality a perfect tilte to the lands they occupied, an act was passed by congress ordering the claims to be surveyed under the direction of the surveyor general. A board of commissioners was also appointed to examine into and adjust equitably the titles to these claims. Aaron Greeley was engaged to make the survey, and he employed James McClosky as his assistant.

The farms or claims, as stated before, front on the river and lake, and were laid out at right angles to the same, or nearly so, and part of them extended back forty arpents (about one and one-half miles) which was called the front, or first concession. Part of them are eighty arpents in depth (about three miles) which embrace both front and rear concessions.

The modus operandi of Mr. Greeley in doing this survey I do not know, but I have good reason to believe that he first meandered the front of each farm and computed the width at right angles; then at the proper distance from the river (the rear end of the claims) he established a base line for a certain number of claims running generally at right angles to the side lines. The course of this base line varies to correspond with the course of the river. Then on this base line he measured

the width of each claim as established in front; he then ran his side lines from the point on his base line to the corresponding point on the river; and as the claims were cleared and cultivated for quite a distance back from the river, it was a very easy matter to have a flag at the river and direct his compass to it, closing exactly as his surveys all do. The lines he ran were generally about one and one-half miles, three miles and some were 295 chains. Tradition tells us that he used a common surveyor's compass to run his lines with. The compass was, in fact, the only kind of an instrument he could use, as the greatest part of the work to be done was through dense forests.

Claim number one (1) is the first claim adjoining the easterly boundary of the town of Detroit. He ran the side lines of it on a course of north twenty-nine degrees west (as he called it) and the rear line at right angles to this line. (The proper course should have been as was established by United States topographical engineer later, north twenty-six degrees west.) And for a distance of about three miles up the river, he ran the lines of the claims parallel with the line of the first one; then, owing to a slight bend in the river, the course of the claims change somewhat, and as the Detroit river and Lake St. Clair change their course, so also do the lines of the claims.

One peculiarity about Mr. Greeley's surveys is, that he never gave a witness tree to his corners. His corners are designated as "a post" and nothing more, except where the corner comes to a tree then he notices the tree. Another peculiarity is that no matter how much meandering there is on one line or another, his surveys invariably close within one or two links; generally they close exactly (on paper) which shows he understood the use of the Traverse tables to perfection.

Mr. Greeley's surveys may not all be perfect, but they are remarkably accurate, taking into consideration the magnitude of the work, the instrument used, and the country almost a wilderness at the time. I think Mr. Greeley did well.

In retracing his lines, I find that they agree perfectly with

the lines of the old ditches which I alluded to above. Mr. Greeley's surveys were made to conform to the finding and confirmation of the commissioners on claims; however, in some cases his surveys did not exactly agree with the finding of the commissioner for the reason that the finding was for a specified width; but when the claims were reduced to actual measurement, they were found to either fall short or overrun. It is a well known fact that Mr. Greeley was somewhat liberal in his measurements, for we generally find a surplus in his surveys.

In 1812 congress confirmed the claims as surveyed by Aaron Greeley under the direction of the surveyor general, making his surveys absolute authority; and thus ended the labors of Mr. Greeley in the vicinity of Detroit.

During the same year (1812) the government provided that additional lands directly in rear of the farms which had been confirmed for only forty arpents in depth, were to be donated to the proprietors of said farms provided the same would not be made to exceed eighty arpents in depth.

Mr. Joseph Fletcher was employed to survey a portion of the said donations, called the "back or second concessions." These second concessions were intended to be a direct extension of the lower or first concessions. The lines of the claims which Mr. Greeley purports to bear north twenty-nine degrees west, Mr. Fletcher calls twenty-five degrees, although it is intended and supposed to be the same course. Thus it will be seen that there is a difference of four degrees between the course given by the two surveyors; Greeley using one degree and forty-five minutes west variation, and Fletcher two degrees and fifteen minutes east variation.

Besides surveying the back or second concessions to a part of the old private claims, Mr. Fletcher surveyed a part of the dividing lines between the outside lines of the private claims and the public domain; he also executed other surveys about Detroit. His surveys are dated 1817 and 1818, and, like Greeley's, were approved by the government and are binding.

After Mr. Fletcher, the next surveyor who flourished in the

survey of the rear concessions of these old claims, is Mr. John Mullett. He surveyed quite a number of them. Mr. Mullett's surveys are dated 1822 and 1823, and he made subsequent surveys from time to time, the last being done as late as 1849.

Mr. Sylvester Sibley was another of the "old timers" who did considerable surveying in this vicinity.

In addition to the above mentioned surveyors, the government employed other surveyors from time to time, to survey unsurveyed second concessions.

In the work of the surveyors who flourished in the old surveys, we naturally find discrepancies, but it is not to be wondered at when we take in consideration the state of the country at that time and the instrument they had to use (the common compass), as the Burt Solar Compass was an unknown instrument. The transit was also unknown to them; the common compass and the theodolite were the only surveying instruments in use at that time; and surveying government lands covered with dense forests with a theodolite was out of the question, as Uncle Sam could not afford the expense of running lines thorugh the forests with a theodolite. He had to be economical, besides, land was cheap and very plentiful and a few feet one way or the other was of little consequence.

But, gentlemen, sad as it may be to relate, these old pioneer surveyors have passed away; they have gone beyond the shore of the great river. So shall we follow sooner or later, and it behooves us to keep "Our Compass" in proper adjustment, that we may not deviate from the true path which leads to eternal peace.

Hoping the Michigan Engineering Society may flourish and increase, and that the year 1895 may bring prosperity and happiness to each and every one of you.

HIGHWAY BRIDGES IN THE MANUFACTURER'S HANDS.

H. K. VEDDER.

It is the purpose of this paper to outline briefly the progress of a bridge from contract to construction, as of possible interest to those whose professional practice may not have permitted a close acquaintance with methods of manufacture; also to present certain considerations which in the mind of the writer indicate the desirability of some scheme for capable inspection of highway bridges.

While the history of some recent bridge lettings in the State of Michigan seems to indicate a probable earlier interest, for present purposes we may assume the manufacturer's connection with a bridge to begin with the consummation of a contract for its construction. This interesting document contains a more or less explicitly detailed plan of the intended structure, together with the usual phraseology supposed to legally bind one party to follow the aforesaid plans, and the other party to pay a certain amount on completion of the work. It may be remarked that in general there is no question concerning the latter item. Not infrequently the plans accompanying and forming part of the contract, consist simply of a diagram or "skeleton" showing the form of truss, on which are marked the strains in main members and also the sizes of such pieces of iron as are to extend throughout the length of main members. Occasionally a show is made of specifying more in detail, but often this will be found to stop with the addition of sizes of pins, and requirements with respect to number of batten plates and the lattice bars. Not all contracts for ordinary highway bridges are incomplete, but it is safe to say that by far the larger number stop short of specifying in detail all items referring to size of connecting plates, number of rivets and many other things understood by engineers to be proper subjects of

requirement and hence proper subjects for specification. No working drawings, of the kind commonly understood by the term, accompany the majority of contracts for such bridges.

It is to be kept in mind that we are dealing with ordinary iron highway bridges, those whose construction is primarily in the hands of the county commissioners, whose length of span seldom exceeds 200 feet, and of which there are hundreds and even thousands erected in this country every year. Concerning this class of structures, Mr. Waddell says that of those spans great enough to require some form of truss 70 per cent are built after the Pratt type. The writer examined the records of a prominent highway bridge company for the year 1894 and found that of 374 spans built in the months from January to November, inclusive, over 90 per cent were of this type. That the Pratt is the most common type is further indicated by the fact that most of the companies provide their agents with printed cuts of such bridges, which are used as part of the contracts. These printed forms picture trusses with from three panels up, on which are blank spaces to be filed by the insertion of stresses and sizes of iron.

When a contract such as has been described, of average completeness, arrives at the office of the bridge company, it is first referred to the engineering staff for checking. A careful examination of the plans is made, to discover any possible error, the main purpose being probably to establish the value of the contract as a business venture. Any slight errors in the plans are noted for correction in the office; more important ones are referred to the agent, or whoever may be responsible for them. Properly checked, the contract passes to the business office, where it figures purely as a matter of bargain and sale. A number, however, is here given to the contract and from this time the number is its main designation. All documents, orders, drawings and shop lists connected with the bridge in progress of construction, bear its number. So also does every finished member when it leaves the shop.

A want mentioned above is now supplied. The drafting

room receives the plans and from them prepares the working drawings, or a substitute for them, which of course must be complete in every detail. While it is not true, as some suppose, that highway bridges are cut off by the yard as it might be, from a continuous stock piece, neither is it to be supposed that any great elaboration of detail drawings is considered a necessary preliminary to the building of one. In Pratt trusses of moderate dimensions, the general form of upper chord members, posts, eye-bars for diagonals and lower chords, etc., are made to conform closely to well-known standard shapes. Given an intelligent pattern maker and foreman of the shop, and these need not be drawn to scale. Written dimensions always outweigh scaled ones; indeed, working drawings should leave no dimensions to be scaled. It is therefore not surprising to find that the drafting room is supplied with printed forms which by the simple addition of the proper dimensions become substitutes for working drawings, fulfilling every purpose of the latter, and effecting a considerable economy of time.

There is no more critical time for the bridge than during this period in the drafting room. There is always danger of a conflict between ample full sized pieces on the one hand, and the manufacturer's idea of economy and profit on the other. Were all contracts made complete before signing, and inspection of the finished structure provided, no such difficulty would arise.

In the case of contracts accompanied by fully detailed plans and specifications, the progress of construction beyond the drafting room is the same as for others, and the routine outlined below applies to all.

In passing, it may be remarked that the builder has a horror of plans emanating from the purely theoretical man. In the designs of one whose knowledge of constructive engineering has not been supplemented by a rather extensive acquaintance with the details of practice the builder looks for and usually finds few or many instances in which good theory appears poor practice. The simple detail evolved in years of practice may

not be well known to the designer. From his perfect theory he may work out a detail perfect in that it fulfills its function and is of necessary strength. But a substitution of the practical detail might effect a lessening of cost at no sacrifice of strength. When connections and other details of any particular form multiplies, as is likely to be the case in the modern symmetrical structures, a cheapening of one of them by however small an amount becomes in the aggregate of no slight significance, and calls for notice in the engineering economy of the structure.

When the working drawings for a bridge are completed, a bill of iron and steel needed for the structure is prepared. Some of this material may be kept in stock, but in general the larger part must be ordered direct from the rolling mills. The progress of construction of the bridge must rest until the arrival of the iron. Here lies not infrequently the explanation of those delays, vexatious alike to manufacturer and buyer, which require an extension of the time limit specified in the contract for the erection of the bridge.

The production of structural iron is a business entirely separate from the branches of engineering employing that iron in construction. The bridge builder has at hand for his work a limited number of shapes, supplied by the rolling mills and shown in their hand books. A list including rectangular and circular sections, I beams, channels and angles, embraces the materials to which he confines his selection, and it is indeed surprising how seldom he goes beyond these limits. Even within them there are laid certain restrictions. The hand books of the iron companies set forth that a beam or angle of certain constant linear dimensions may be given a thickness of web or flange varying between stated maxima and minima. There being no statement to the contrary the natural inference is that within these limits any size can be obtained with equal facility. But experience proves such a conclusion to be far from correct. Certain sizes have acquired a commercial importance much beyond other sizes in the scale of variability. Often

no good reason for such preference can be found but the fact remains. In obedience of the law of demand governing supply, the rolling mill will be prepared to furnish a quantity of 8 inch channels, 12 pounds per foot, with less uncertainty than of 16-pound channels having the same height; and so for other sizes and sections. The successful designer must be an encyclopedia of such and all other matters that can by any possibility affect the time necessary to complete the structure or the cost of it.

Upon the arrival at the factory of the iron ordered, the shop work of construction is ready to begin. In the drafting room have been prepared lists of pieces required, designated "rivet list," "hammer list" and "forge list," according to the character of the work necessary to fashion the parts. These lists are sent to the foremen of the several departments along with the material needed. For compression members, which are usually columns built of plates, angles and channels riveted together, patterns must be prepared. They are made of wood strips or frames in which are bored holes at such distances apart as the drawings show for the rivets. The work is laid out by applying the pattern to the proper piece of iron and marking through the holes with a steel tool, the exact center of each rivet hole to be made in the piece. The rivet holes are then punched out and the parts of which the strut is to be built up are assembled and held in place by being temporarily bolted. One by one the bolts are removed, as their places are supplied by rivets pressed to place while hot by hydraulic or compressed air riveting machines. The ends of struts that are to abut directly against others are then milled to true surfaces, and the pin holes are bored with exactness. For Pratt trusses, the upper chord members, inclined end posts and vertical posts pass through all of the process of pattern-making, punching, riveting, milling and boring. Floor beams, if built up of plates and angles, require patterns, punching and riveting, as do overhead struts and portal braces. The same may be said of tension members when they are built in strut form for stiffness.

In general, however, tension members are of simplest cross-section with provision for end attachment in the shape of loops or circular openings. The most common form is perhaps the well known eye-bar, which is used almost exclusively for lower chords and main diagonals.

The eyes of bars used in highway work are usually made by piling sufficient metal at the end of the bar, heating, and then forcing the end into eye-shape in a die, under the action of a heavy steam hammer. The eyes are then bored truly to sizes of pins and the bar is finished except for painting. Loop rods of round or square iron for counters or wind bracing find a place in the forge list. When made in two pieces, to admit of adjustment of length by means of a turn-buckle, the loop is first forged on each piece, then the other end of the bar is upset and a thread is cut on the upset portion. The round portion of the loop is then bored for pin bearing. Most of the wind laterals are made in one piece and provided for adjustment by a nut on the upset screw-thread end.

Yokes for supporting the floor beams require bending, upsetting and the cutting of threads on the upset ends. With the lathe work on pins the list of shop operations is finished, but not all the smaller pieces forming part of the bridge have been mentioned.

When the time comes for shipping to the site of the bridge there must be included from the well stored stock room a number of extras, namely, sleeve nuts, shoe nuts, lateral bolts, wood screws, pipe for railing, pipe sockets and caps, bolts of several kinds, fillers, spikes and nails, and paint. The main members usually receive one coat of paint or oil before leaving the works and another coat is given the finished structure after erection. All material is weighed before shipping, for comparison with the estimate made before building the bridge.

The only point worthy of notice in the erection of the bridge is the ease with which a gang of common laborers under the supervision of one man of some experience will put the parts together. A false work consisitng of a few trestle bents resting

on the bed of the stream, furnishes the base of operations. An improvised traveling crane is needed for high truss bridges. A few days' work suffices for the erection of a considerable span, complete with joists and floor for travel.

Mention has been made in several places above of the general incompleteness of plans forming part of the contract, and of the uncertainty attending matters of detail, both pointing to the necessity for greatest care and considerable knowledge of bridge engineering on the part of the purchaser of a bridge. The necessary details often omitted in contracts may amount to 10 per cent of the whole bridge weight, and represent a considerably greater part of the whole cost.

To insure satisfaction in details, complete working drawings should form part of every contract, which should conform to safe standards and the finished bridge should always be subjected to tests with observations for deflection. The matter of standards is one worthy the attention of this association.

When business interests and engineering interfere, business interests are likely to come out ahead if there is no law to prevent. In the usual order of things, from the contract to the finished structure the bridge manufacturer is a law unto himself, and the inference is plain. Under such circumstances perhaps the best advice that can be given to the buyer who is wholly ignorant of the laws of mechanics and strength of materials is that he be sure to pay a high price for the bridge. In case of competition let him take the highest bid.

Not always does danger arise only from an overpowering itching for profit. Carelessness or negligence may make improper arrangement of materials, which if properly disposed, would meet all the demands of strength and safety. The writer once acted as inspector of two Pratt truss highway bridges which were well designed and passed through the shop built on honor. But after they were erected and pronounced complete by the builder, the posts were found to be wrongly placed, the lightest ones being near the ends of the spans and the heaviest ones at the middle.

Railroad bridges are usually built under the supervision of more than ordinary engineering ability. Yet when, in 1890, the railroad commissioners of New York state made a critical examination of the bridge structures existing on the railroad lines of that state they found a surprising condition of affairs. The result of the inspection was the mandatory reinforcement of fully one-fourth the whole number of bridge structures, because of their failure to come up to proper standards. The belief is shared by many that a similar examination of highway bridges would be not less fruitful, and might as properly be undertaken.

SPECIAL SEWER ASSESSMENTS.

M. C. TAFT.

The methods employed in assessing for sewers in different cities and towns vary greatly and the problem of making a sewer assessment that shall be exactly just to each one assessed, is one that perhaps may never be solved.

But if we cannot fully solve the problem, we should still endeavor to adopt a plan of assessment that shall be as fair and equitable as possible.

Among the many plans, the following are perhaps the most prominent for assessing the cost of sewers:

(1) In proportion to the benefit received by the adjoining property.

(2) In proportion to the value of the adjoining lot.

(3) According to the area of the adjoining lot.

(4) According to the frontage of the adjoining lot.

To these might be added the plan of spreading all or a part of the cost on the general tax roll.

In considering the various methods of assessment, it must be remembered that a properly planned and constructed sewer is a permanent improvement, and that a piece of property may receive a benefit from the sewer several years after construction, even though it may be of no particular advantage to it at the time of building.

The objection to an assessment according to the benefits received lies in the difficulty of determining just how much each adjoining property is benefited, and in the fact that the benefits received may vary from year to year.

The judgment of different persons will differ so greatly as to the benefit each property receives that a great deal of dissatisfaction and ill-feeling will be engendered no matter what amount is decided upon.

The difficulty of assessing according to the value of the lot lies in the fact that lots in the suburbs or residence portions of the town are worth only a fraction as much as those in the business center, and perhaps receive just as much benefit.

Again, the value of a lot changes from year to year.

Also the sewer is apt to cost just as much on a street in the outskirts of a town as in the very center.

When only one method of assessment is employed, the plan of assessing in proportion to the area of the lot drained, is, perhaps, the most equitable way of imposing a tax for sewer purposes.

The entire cost of the sewers for the district to be drained, including cost of outlet, main sewers lateral sewers and any other items that may occur, should be taken, and the cost assessed against any lot should be in proportion as the area of that lot is to the total area of the district sewers.

Where the assessment is in proportion to the frontage, the same general plan is followed, with the exception that the frontage of the lot is taken instead of the area.

Here an injustice arises on account of a difference in the depth of the lots, the irregular shape of some lots, and because some lots are on a corner.

In the case of the corner lot, the unfairness can be adjusted by assessing against only one-half of the frontage, limiting the size of a corner lot to within certain dimensions.

Probably the most satisfactory results can be obtained by judiciously combining two or more methods as local conditions may require, thus correcting any injustice that might arise from using any one method singly.

Especially is this true of a combination of the plans of assessing according to the area and frontage of the adjoining lots.

The above methods of assessing apply particularly where the sewers for the whole district are built at the same time.

Where the sewers are built piecemeal, the plans and estimates should be made for the whole town or district to be

drained. A sewer fund could then be created by either a general or a special tax for enough to build the outlet and the main sewers. As the lateral sewers are built, the remaining part of the estimated cost could be assessed against the adjoining property. The remaining part of the cost due from the property adjoining the main sewers, could be assessed when the mains are built, when the property is connected, or when the whole system has been built.

In designing a system of sewers, very often deep cuts are necessary in some places in order to accommodate other portions of the district.

In assessing for the connecting sewers, by which is meant that portion of the house drains lying in the street, it is manifestly unjust for those adjoining a deep cut to pay more than those for whose benefit the deep cut was made, but who perchance adjoin a shallow cut.

Either the average cost of a connecting sewer should be assessed against each property connected, or the average cost per foot should be taken and the cost assessed according to that.

In the latter case, the length of the connecting sewer should be reckoned from the center of the street on which the sewer is built; this is to equalize matters, when for some reason the main or lateral sewer is thrown to one side of the street.

There are many other plans of sewer assessment, which are, perhaps, according to some people's judgment, fully as good or better than those mentioned above.

The above methods must be taken in a general sense and they may be modified or altogether changed by local circumstances.

In many places there is a very good practice in vogue, of dividing the total assessment into several parts, and spreading them over a series of years, making one part payable each year; of course charging interest for the parts carried over the first payment.

By this means, those whose income is small are enabled to easily pay their assessment, which might be quite a hardship if they were compelled to pay it all at one time.

If any one wishes to pay two or more parts of the assessment at once, and thus save interest, he is allowed to do so.

This scheme is more fully discussed in the book entitled "The Separate System of Sewerage," to which I am also indebted for many of the points in this article.

THE PRESIDENT: The paper is before you for discussion. The matter of assessing the cost of a sewer is something of a problem, as all city engineers have found who have had that in hand.

COL. MUENSCHER: I spent a good many years in city engineering and this was one of the most difficult problems I had to contend with, and I don't suppose there is a city in the United States that has yet adopted a really equitable system of assessments. The assessments are made by piecemeal, as the sewers are built, and there is always more or less injustice, and perhaps it is impossible to remedy that, where a system is once established, but for a new place, where they are about putting in a system, it seems to me that the plan I proposed to Grand Rapids a number of years ago is the proper one.

The benefits of sewerage are two-fold, special and general.

The special benefit is the opportunity given the owner of property to drain his house, lot and cellar. That benefit he does not receive until the sewer is built in front of his property, and he should not be assessed for it until he receives the benefit.

The other benefit is general, in the improvement of the health of the city. That, *every* man receives, and for this every citizen should be taxed. For that reason a system of sewers should be built, partly by general tax, and partly by special tax. The general tax should go into a general sewer fund, from which all the sewers should be constructed.

Another point is, that it does not make any difference to a man whether the sewer in front of his place is six inches in diameter or six feet. The one will carry off all the sewage of his house, as well as the other, and there is no reason why he should pay any higher assessment to build a six foot sewer, than a six or eight inch sewer. That is another thing in which there is great injustice done. They will tax a man three times as much for a large sewer as for a small one.

Another thing is, that in some streets the cost of building a sewer is much greater than in others, and yet in most cities they will make a man pay a great deal heavier assessment because a sewer will cost more, and especially is this the case in laterals. Most cities assess the whole cost of a sewer on the adjoining property. It seems to me that the only fair way of averaging this special benefit is to determine on an average cost of such a sewer as is necessary to drain a man's property.

For instance, suppose we say a 12 inch sewer is an average size, and you determine it will cost $2.00 a foot on an average to build the sewer, or $1.00 a foot on each side. Then fix upon that as a permanent basis of special assessment, and when a sewer is built in front of a certain piece of property, no matter whether a main or a lateral, expensive or cheap, tax that man $1.00 a foot front, to a certain depth, and when he has once paid that let that be the end. Never charge him another cent, except his share of the general sewerage tax. Let that go into the general sewer fund, and pay the cost of the sewer, whether large or small, out of the general fund. If it costs less than what the special assessment brings, there is something left. If it costs more, take the excess out of the general sewer fund. In that way, every man pays the same tax, in proportion to his frontage. The value of the property should not have anything to do with the special tax.

MR. SEARS: How do you arrive at that special tax?

COL. MUENSCHER: Almost every engineer can find out what it is likely to cost to complete a new sewer—the average cost.

It is not necessary you should be exact. Fix on some definite sum, and make it permanent.

MR. SEARS: All above that you would make a general tax. I think your views on that question are sound.

COL. MUENSCHER: In that way, the public pays for the general benefit received through the improved health of the city.

MR. SELLERS: Does each man make his own connection with the sewer?

COL. MUENSCHER: It would be wise to include the cost of carrying the branch to the property line, because it very often happens, especially where the street is going to be paved, that all connections should be made before the pavement is down.

MR. SELLERS: Would that come out of the general fund?

COL. MUENSCHER: Yes; or make the assessment large enough to cover it. Then a man knows, when he has his certificate, that it is paid. That becomes a part of his property, and when he sells it (the first inquiry of a buyer will be if the sewer assessment has been paid) he can say, here is the receipt, and the purchaser knows that he will never have to pay another sewer assessment.

MR. TAFT: We have that system in Kalamazoo.

Q. It seems to me that the difficulty is that the first sewering is the most expensive. If there is only an average tax, where are you going to get the rest?

COL. MUENSCHER: General tax.

Q. You must assess for that first sewer a larger assessment than an average.

COL. MUENSCHER: I wouldn't make any larger special assessment. I would raise a general sewer tax to meet this extra expense.

MR. APPLETON: In Lansing, substantial justice is done, as follows:

The engineer has nothing to do with the sewer. When an application is made for a sewer, if there is no sewerage suitable, the engineer is ordered to make an estimate. He makes

an estimate of the cost for that district. The sewer may only be dug one or two blocks. One-sixth of all sewers are built from the general sewer fund, five-sixths then remains to be paid by the persons benefited. As I said, the enigneer has nothing to do with the assessment. He has to make an estimate, and from that estimate the assessor works.

They are assessed according to benefits, and I believe it has generally been done as nearly fair as the assessor can make it. I have known cases where a man going to be immediately benefited by a sewer will have to pay as high as $15.00 or $20.00. The whole district will be assessed, and away off where the sewer may not get in five years, a man might have to pay a dollar. As soon as that sewer is extended, there is another assessment for the whole district, and then the benefit to be derived from the extension falls the heaviest on the extended portion. Then, as it is still further extended, the same system will be observed.

We like to run our sewers in the gutter lines, and then, whenever there is any break up, we get at it without breaking up the middle of the street, and the street car now is another objection. At the opposite side, they pay later, because their connection will cost more. The engineer is bound to make connection to each lot, and the lot owner has the privilege of selecting the spot where the connections shall be put in. They do not always connect with the sewer. It costs sometimes $20.00 to make a connection. That is marked on the sewer, and whenever that man does get ready to connect, he notifies the engineer, who locates the connection for him, and they dig down to it and the thing is done. So the person getting the benefit pays the heaviest tax, as soon as he gets the benefit, but all over that district, the assessment is made as it is intended it shall be, when the whole sewer is complete.

In Lansing there is a large district, all draining down into one of our finest streets—Ottawa street. The system was designed originally by Mr. McVean, but after I came in it

had to be materially altered, and in changing, the greatest difficulty we have had, is in changing from one district to another, when you go to put in another district.

MR. SELLERS: In that very respect, and the extension of the boundaries of the district, has come a large part of the injustice. I know many cases where the assessments are not just. I know of one case where the cost of each extension of the sewer is spread upon the entire district, irrespective of benefit.

I think if Col. Muenscher's plan could have been adopted on the start, so that when a man paid his tax, that would be the end of it, there would not have been so many unjust assessments.

COL. MUENSCHER: The plan that Mr. Appleton speaks about is probably the one in use in nine-tenths of our cities If you could have an assessment board composed of three angels, to make the assessments and keep them permanent, it would work all right, but just see how this thing is generally done. The city council will appoint Tom, Dick and Harry as assessors. They will give them the amount to be raised. They will get into the council room, and have their cigars, and sit down and tell stories and sing songs, and finally get to work. And Tom will say, well, I guess we better tax that fellow about $10.00, and this next one the same, up in that block; I guess they will be benefited about $10.00.

Well, but what about that next block? Well, suppose we put $9.00 on that block. Down she goes. And the next, $9.00, so it goes. They do not pay any attention to previous assessments, it takes too much time. And that is the way it goes. One assessment is made after another, and when it is done, you will find that the ones the assessors think can pay the most, will perhaps pay two or three times their fair share. I know that in Grand Rapids they don't pay any attention to the old districts. They will make a district, and a purely arbitrary tax. The councilmen do it. They will make a district with arbitrary boundaries, and they will assess the cost of a certain

sewer on that. After a time, the sewer is to be extended, and they will go to work and make a new district, and have it lap over on the other district. Next year, perhaps, there is a sewer to be built in another street, and they will take half of this district to help build another sewer.

MR. SELLERS: If these boundaries are established according to the lay of the ground, and are just and equitable, if a petition comes in, signed by any number of men, the council do not change the boundaries.

COL. MUENSCHER: And even where you make your districts, according to the lay of the land, you cannot make them so that the taxation will be equal, and the people in the favored district will get their taxes at about one-half what the other people pay.

In the one district, it is low ground, where the streets are going to be filled, and you may not have to cut more than five or six feet. People in that district get their share for one-half what it costs the other, and maybe their benefit is more, if the ground is wet.

MR. APPLETON: In regard to those three angels, for assessors. Up to within a year ago, we had but one assessor, and the whole city swore at him. Now we have three assessors, and there is a fair howl. They have more men to swear at, and beside that it does help the engineer wonderfully.

MR. HODGMAN: In regard to Tom, Dick and Harry, Col. Muenscher described how they get together, and make the assessments without going into details. But suppose they did undertake to investigate this whole thing, when they got through, would they get a more just estimate—Tom, Dick and Harry, I mean?

COL. MUENSCHER: The majority of the Tom, Dick and Harrys wouldn't.

MR. SEARS: I am pleased with the way this question was discussed by Col. Muenscher. It is expressed better and clearer than I could have put it. In my opinion, in the majority of cases, instead of putting in the lateral to the curb

line, it is left out, and the whole thing is destroyed for want of a system, and I think the system suggested by my friend is the sound one.

MR. MARHOFF: There is one question that is the source of a great deal of trouble—corner lots. We have several cases in Battle Creek. I have one in mind now that came into a sewer district assessment, a triangular lot, with streets on all sides, and the width of the lot on the narrowest side is about 80 feet.

MR. SELLERS: In Lansing they assess the frontage of the corner lot the same as the frontage of an interior lot, but when they go down the side of the street, they take into consideration that there are building lots the long way of the lot. He is therefore assessed not quite three times the tax on the other side of the lot.

COL. MUENSCHER: I would not make any distinction between a corner and interior lot. Assume some uniform size for a lot, and anything beyond that would make the assessment a little larger. If 100 feet is the usual depth of land, let that be the standard. If a man lays off his land into 150 foot lots, tax him a little more. But a corner is no more benefited by a sewer on two sides than on one side. Let that be his advantage.

MR. APPLETON: Our lots are laid out uniformly—four rods front and ten deep, 166 feet. Now, as land is becoming more valuable, they are almost invariably putting a house on the back of one corner lot, so they really serve for two families.

COL. MUENSCHER: You should limit the size of your corner lot.

If the lots are all uniform, everyone shares alike, but after the property has once paid its uniform tax, it should never be charged another cent.

MR. SELLERS: Suppose the lots are 100 feet deep and it takes two lots to compose the block, who will pay for the sewer down the side street?

COL. MUENSCHER: General fund.

MR. TAFT: There is a special application of this question in Kalamazoo. A separate system of sewage is used, and con-

sequently the cost is not very large. I think the average cost up to this time, runs a dollar a foot for one sewer all over town.

This means everything—not including the connecting sewers. At first they started out on a different plan, but which was afterwards corrected. The plan now is to have a general sewer fund. Each year there is a certain amount appropriated to that fund, according to what the committees ask, and it is spread on the general tax roll. As each sewer is built, the frontage on both sides is assessed 33⅓ per cent per running foot, and all the rest of the cost comes out of the general fund. We limit each corner lot to four by eight rods, and assess for half of the frontage. For instance, if the sewer comes down to the short end of the lot, the person on the corner lot has to pay a little more, but he has the added benefit of being able to build a house on the rear end of his property.

COL. MUENSCHER: It is practically the same thing I proposed.

MR. TAFT: Sometimes there is an injustice there. When a man has, for instance, a lot that is ten rods deep, he is benefited more than a man with a lot only eight rods deep, and that is the reason that in my paper I spoke of the combination of the frontage and area plans. Triangular corner lots could be fixed in this way, and a just assessment made, by taking the area into consideration.

THE PRESIDENT: In Lansing, as I understand, they assess the cost of the first construction upon a large portion of a certain district, upon the property immediately adjacent, the balance being spread over the entire district, and then as the sewer is extended, the adjacent property takes the larger share of the cost, and the balance is spread over the whole district. It seems to me that that is depending entirely upon the good judgment of the assessor. No matter how honest he may be in his judgment, he is liable to judge far differently from his predecessor.

The system proposed by Col. Muenscher, I think, is perhaps the most equitable one, except in this respect. I don't believe

you ought to fix a price for the minimum lateral sewer you are going to construct for all time. For instance, in 1890, the cost of this 12-inch sewer, if you limit that as your minimum, might be $1.00 a foot on each side. The past year, and perhaps this year, work will be done for about half what it was done five or six years ago. Why should I pay today, when material is so much cheaper, just what my neighbor, or some one in another portion of the city, paid five or six years ago, when everything was higher? It seems to me that a general average for the year should be struck, and an assessment made for the lateral on that.

COL. MUENSCHER: That would be corrected in your assessment in the general fund. Your special tax would be just the same, but your tax would be relieved, when it came to taxing for the general fund.

Under this system, if a sewer tax is not paid, the man intending to purchase, knows just what he is going to pay some day. If you change from year to year, he doesn't know what he is going to pay.

MR. HODGMAN: It strikes me that the same principle applies there that applies in the question of boundary lines. It is more important to a man to know that his boundary lines are fixed, than to have the exact amount of land, and it seems to me that it is more important that a man shall know just what he is going to pay, than to know that he pays just the right amount of taxes. We cannot anticipate ten, twenty or forty years what the changes in prices are going to be.

THE PRESIDENT: The matter of special assessments, it strikes me, is largely arbitrary anyway, and that it is dependent very much upon the judgment of the person making the assessment, whether it is an assessor appointed, or in the hands of the engineer having charge of the construction. I do not believe you can make any set rule, to apply in every case.

MR. HODGMAN: I think Col. Muenscher has the best plan.

COL. MUENSCHER: You leave it to men who will be influenced by personal friendship, and some perhaps, in the larger

cities, by a little five dollar bill, for the men who are appointed on boards of assessment in our larger cities will be influenced, if not bribed, by personal friendship.

THE PRESIDENT: Even under the colonel's system, the matter is somewhat, in fact largely, left to the judgment of the assessor, and it is in a measure arbitrary with him. The judgment comes in, in spreading the special assessment upon the district decided upon, to spread that special assessment.

COL. MUENSCHER: There is no district about it. The special assessment is assessed on the property that the sewer fronts on.

THE PRESIDENT: But that itself forms a district.

COL. MUENSCHER: Yes; but the law is to fix what that tax shall be.

THE PRESIDENT: To illustrate. We have practically the same system in Saginaw. The law fixes, that is the ordinances say, that the cost of a lateral sewer, a 12-inch sewer, shall be assessed upon the property immediately adjacent. The cost of the sewer, over and above that, shall be assessed on the city at large. It goes further, and says that the assessment district for a lateral sewer shall be carried to the center of the block. Now, when we have a rectangular subdivision, we construct our sewer, perhaps a lateral sewer, through the center of the street. The assessment is carried back to the center of the block on each side, and if these are all uniform lots, then all get a uniform assessment. But suppose these lots on the corner have been cut up, the man originally owning them has taken these corner lots and sold them off in three parcels. That entire district gets the same assessment, must necessarily have the same assessment, whether divided into that form, or as it originally stood. Now how are you going to divide the assessment against those two corner lots in an equitable manner? You say we will put the entire cost on that one piece, fronting on the street, or put it on those two blocks entirely, and divide it in some equitable manner. There is where I say, it is in a measure arbitrary.

COL. MUENSCHER: That is a matter of detail that could be regulated in the ordinance.

THE PRESIDENT: It is almost invariably left to the judgment of the assessor, and is necessarily an arbitrary matter.

MR. HODGMAN: It strikes me that that objection to Col. Muenscher's plan—that there is liable to be injustice arising because it is to be left to the judgment of the assessors—if it is an objection to that, it is an objection to *every* plan. There isn't a plan, possible to be suggested, but that the judgment of some man must be employed to fix it in the first place. It is an objection to making an assessment at all. All men are human and liable to error.

MR. SEARS: Use a dry earth system, keep it out of the water. I have done it for ten or twelve years. Cart it out into the fields to raise corn and wheat and milk and butter.

COL. MUENSCHER: I am perfectly aware that it is impossible to adopt any system which will apply universally, without any exceptions, but my object would be to take this matter as much as possible out of the judgment of any one. Make the assessment absolute, fixed by law; because with the best of intentions there will be injustice where the matter is left to the judgment of an assessor. Have the ordinances fixed, so that just as far as possible all the assessments can be made by the city clerk, by turning to the ordinances and the map of the city and observing the area and frontage of a man's lot, and its location with reference to the sewer. It is uniform all over the city, and not changed from year to year.

THE GRAND RAPIDS PLASTER QUARRIES.

C. H. REDMAN, GRAND RAPIDS.

Two underground and four open quarries comprise the plaster quarries of Grand Rapids and vicinity. The former are on the north side of Grand river and distant therefrom about one-fourth of a mile, and are on the south slope of the bluffs. On the opposite side of the river, about one-half mile farther up stream, are three of the open quarries. Two of these are separated from each other about one-fourth of a mile. Near the lower one of these and 600 or 700 feet distant is a new quarry now being stripped. The fourth open quarry is at Grandville, six miles down stream.

The quarries in the immediate vicinity of the city are in general very much alike. Each has a bed of gypsum about 12 feet thick, the elevation of which is very nearly the same. A very slight dip is found extending northeast. The elevation of the bottom of the 12 feet bed in the open quarries is about 7 feet compared with low water or the city datum. That of the underground quarries is 9 feet 6 inches, making a dip of 2 feet 6 inches in three-fourths of a mile. It is not regular, however, and the 12 feet bed is not a continuous one. The river cuts the bed in two, as borings to a depth of from 12 to 15 feet below low water fail to give evidence of rock of any kind. An out-crop, however, is seen at the north edge of the river opposite the lower quarry. Not only is the bed cut by the river, but on the south side of the river is considerably broken and irregular. The absence of the gypsum in the river bed may be due to the abrasive power of the water, which centuries ago gradually wore away the rock to a considerable depth and has since filled in with sand and gravel.

The combined area of the three open quarries is between 5 and 6 acres now quarried. The plaster rock is covered with a

variable thickness of clay, gravel and loam. In the Godfrey or upper quarry, we find over the 12 feet of gypsum the following section:

Clay, gravel and loam of variable thickness.	
Limestone	7 inches.
Shale	12 "
Limestone	6 "
Shale	9 "
Impure plaster rock	6 "
Shale	3 feet.
Plaster rock	1 foot.
Shale	3 feet.

In the other two open quarries no rock is found above the 12 feet bed. But below this bed in the new quarry is a flesh colored pencil rock 4 inches thick, under which is found 18 inches of shale, sandstone 3 feet, 9 inches, and 24 feet of plaster rock.

The two quarries on the north side of the river, are, as stated, on the south slope of the bluffs, the highest points of which are about 130 feet above the river. The original openings into the quarries were made thorugh vertical shafts, which are now used for purposes of ventilation. Entrance is now made on an incline of about 1 foot in 8 feet, on which tramways are laid leading to the mills, some 200 feet distant at the foot of the bluffs.

Prof. Winchell has obtained the follwing section through the lower quarry:

		Feet.	Inches.
19	Loam, variable in thickness.		
18	Clay, yellowish and plastic	3	0
17	Shale	3	0
16	Plaster rock, a series of irregular, alternating layers of arenaceous limestone and shale inclosing many masses of gypsum	5	0
15	Limestone, argillo, arenaceous, called flint	4	0
14	Shale, blue, thinly laminated, uniform	4	6
13	Water limestone	0	8
12	Shale	1	0
11	Water limestone	0	10
10	Shale	3	0

		Feet.	Inches.
9	Plaster rock, composed of plaster and clay	2	0
8	Shale	3	0
7	Water limestone, which in upper quarry passes into gypsum	2	0
6	Shale	3	0
5	Gypsum	5	0
4	Shale	0	9
3	Gypsum	12	0
2	Shale	2	0
1	Limestone and gypsum	4	0
	Total	58	9

In the upper quarry he gives the following:

16	Loam	6	0
15	Clay	3	0
14	Water limestone	1	0
13	Shale	4	0
12	Gypsum	0	10
11	Shale	1	3
10	Water limestone in thin layers	2	0
9	Shale	3	0
8	Gypsum	1	6
7	Shale	3	0
6	Water limestone	0	10
5	Shale	4	0
4	Gypsum	6	0
3	Shale	1	3
2	Gypsum	12	0
1	Gypsum, rather hard, dark color, through which excavations are not extended	0	0
	Total	49	8

Nos. 1 and 2 in the upper quarry, correspond to number 3 in the lower quarry; No. 3 of the upper to No. 4 of the lower; No. 13 of the upper to No. 14 of the lower; No. 14 of the upper to No. 16 of the lower; No. 15 upper to No. 18 lower; so that the beds Nos. 15 and 17 of the lower quarry have no equivalent in the upper quarry.

The 12 feet bed of gypsum is a pure and solid mass, veined with the bluish color of shale; reddish at the top, below becomes more bluish as a mass. In the center has much the

appearance of hornstone in luster and fracture. It is translucent, compact, finely grained and homogeneous. It is from the center that large blocks are taken, hardened and polished for ornaments. Below the center, the bed is of a mottled appearance and of a coarse fibrous structure.

An analysis of an average sample from these underground mines gives the following composition:

Water	20.8445
Silicic acid	trace
Alumina and oxide of iron	.5354
$H_2 SO_4$, Sulphuric acid	46.2257
Lime	32.0385
Pottassa	.2115
Soda	.0140
Chlorine	.0078
Total	99.8774

The analysis shows the rock to be very free from impurities, thus making it quite valuable.

The combined area of the two underground quarries is about 33 acres. Eighteen acres of this are in the upper quarry. The area of this bed of plaster rock is unknown. It is known to exist over quite an extended territory. The Hon. C. W. Garfield, while boring for a well on his premises two miles distant from the nearest quarry, struck a bed of plaster rock 80 feet below the surface, between 20 and 30 feet thick. This is very nearly on the same level with the 12 feet bed in the quarries. Returning to the underground quarries, we find that from the entrance, tracks are laid, diverging so as to make an angle of about 120 degrees and extending back, in some places about 1,000 feet, which at this distance is about 130 feet vertically below the surface. Mules haul the rock out to the entrance, where the loaded cars are attached to a chain from the mill, to which they are conveyed by machinery.

As will be seen from the section of rock given, a bed of from 5 to 7 feet of gypsum is directly above and next to the 12 feet bed. This is not disturbed and forms the roof or ceiling of the quarry. Supports of red, white and black oak logs from

12 inches to 24 inches diameter are used, spaced irregularly from 6 feet to 15 feet. Pillars of the gypsum 20 feet in diameter are left standing at distances not exceeding 60 feet for addition security.

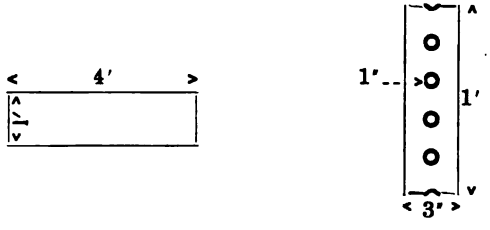
The upper quarry has 3 so called "benches;" a wet bench, a salt bench and a dry bench. The last is the portion of the quarry worked. A leak found over head in the wet bench, renders work in that section of the quarry somewhat dangerous, while the rock found in the salt bench is evaporated with extreme difficulty. The portion of the quarry worked is very dry and no difficulty is experienced in quarrying the rock. The lower quarry is somewhat wet and somewhat dangerous to work. Extreme care is taken in supporting the roof, as one "cave in" was experienced in this quarry several years ago. No salt is found here, but a flinty rock is found instead.

The blasting is done with giant powder, two pounds being sufficient to loosen from 8 to 10 tons of the rock. A hand drill is used. The horizontal veins extending entirely through the 12 feet bed, making lines of least resistance, make it easy to secure large blocks of regular form. The writer saw one block 12x3x3 feet whose weight is about 8 tons. It is being hardened and polished by a Chicago firm and will be cut into slabs and used for pilasters, casings, sideboards, mantels, or other ornaments. The polishing and hardening are accomplished by some chemical and electrical process, kept secret by the company. When treated in this manner the gypsum presents a beautiful mottled appearance.

The process of manufacture is very simple. The quarried rock varying in weight from 30 to 100 pounds is thrown into an ordinary stone crusher, after which it is ground either on mill stones or with pulverizing machines. If for land plaster this is the end of the process, and the material is carried by conveyors to the bins. The calcined plaster, or stucco, the pulverized plaster is put into large iron kettles from 8 to 10 feet in diameter and 8 feet deep. They are filled to within two and one-half feet of the top, which space left is called

"steam-space." Heat is applied and the material is constantly stirred to prevent burning. From three and one-half to four and one-half hours are required to evaporate the water after which the kettles are emptied and refilled. After evaporation, the plaster is carried by screw conveyers to bins, where it is spread in thin layers to cool.

The capacity of a 10 feet kettle is about 150 barrels per day of 14 hours. This will give the two mills on the north side of the river a capacity of about 900 barrels per day, or for 300 working days 270,000 barrels per year. Twenty-five per cent of this, or 67,500 barrels, is more nearly the annual output for the two mills. Each of the two mills grinds annually the rock from about one-half acre or about 20,000 tons. The total output of the five mills combined is probably not far from 250,000 barrels per year. It is commonly known that the land plaster is used as a fertilizer and disinfectant. The calcined plaster has many uses. For hard-finish on walls, being mixed with different coloring materials which give a very pretty effect. For very fine wall finish it is reground and various chemicals are applied as glue, zinc, common salt and various paints. The glue acts as a retarder to the setting. It is used by glass-polishers in which to hold the glass while the polishing is being done. In terra cotta work it is used quite extensively, one kind of which termed macilite is of interest as having been used in the construction of the World's fair buildings. A cross section and plan of a slab is given in the accompanying figure.



Calcined plaster, reeds, fibre and cork are used in its make up. The plaster renders the finished product fire proof; the reeds give it strength; the fibre adhesiveness and the cork ren-

ders it light. The rock taken from the new quarry spoken of is shipped direct to Chicago and manufatured into macilite.

MR. REDMAN: It will be noticed that it seems to have about the same elevation all over. I noticed a few days ago that Mr. Garfield had struck a bed of plaster, and he said he found it about eighty feet below the surface, and the elevation of the surface at his place is about 97 feet, which would bring the bottom of his rock-bed about the same as the other quarries, which shows that the extent of this plaster rock is unknown, and it seems to be indefinite. It extends all over the southern and western portions of Grand Rapids.

COL. MUENSCHER: Did you say there was a stratum of rock salt?

MR. REDMAN: There is in some places. The fact that the river seems to cut the quarries in two, is something I would like to understand. I thought it might be because the erosion of the rock might have taken place a great many years ago, and filled in since.

MR. RUMSEY: The best rock has not been mined all all. It is deep, about 300 feet I think, and it is a good deal thicker but better quality of rock. Mr. Powers is now thinking of operating it.

COL. MUENSCHER: Where is that?

MR. REDMAN: He is surveying on the bank of the canal and intends to mine under the river. That shows that the river has not cut through and that the table rock extends under the river.

MR. STRONG: You speak of different thicknesses of this strata, but I do not understand whether they work the thinner strata.

MR. REDMAN: The portion that is worked is the 12 feet bed, and we work all of that. You will see here a sample of pure gypsum. That is taken from the shale on the roof of the quarry. A twelve feet shale.

MR. STRONG: In making the calcined plaster is there any refuse?

MR. MUENSCHER: They simply boil out the water of crystallization—what is left is the dry calcined plaster.

MR. STRONG: Is there anything sorted out from it?

MR. MUENSCHER: I believe not.

MR. SKEELS: The object of Mr. Powers boring is to make marble from this gypsum. If any of you are in Grand Rapids step into the Morton House. They have quite a number of marble columns made under this patent, from this gypsum. The stone, or rock rather, that Mr. Powers is after, is a finer quality, as Mr. Rumsey says, and their intention is to ship it to Chicago, or bring that part of Chicago to Grand Rapids, and manufacture marble for tables and columns, and for all uses that ordinary marble is now put to.

Q. Isn't there something in regard to the time it takes for hardening—I suppose it varies with the size of the article?

MR. SKEELS: I don't believe I can answer that question. The firm from Chicago which is hardening the sample have been at work but a little while. At the time I was there, they had just commenced. I understand the process of hardening is a secret, and the length of time I do not know. The sample I saw, one of those large blocks, was certainly very beautiful, after being polished and hardened. The Assistant Superintendent showed me through the quarry, and in showing the sample, he took some water and washed it and it certainly was very beautiful.

MR. REDMAN: The largest amount of this plaster is used in glass factories. It used to be used very extensively as land plaster, but they do not use it at all now, for some reason.

MR. APPLETON: I would like to know whether the notion of its fertilizing land, is exploded, or whether it is the depressed condition of agriculture, simply, that it does not pay to put anything on?

MR. HODGMAN: I don't know but possibly the farmers in our section of the country could throw a little light on the subject. They used to use a large amount of plaster.

There was a procession of teams, all day long, going to Grand Rapids, after plaster. Some few years ago, the farmers got the idea, that there was a combine at Grand Rapids, putting up the price of land plaster above what it was worth to use and they made up their minds they wouldn't use any more plaster.

MR. RUMSEY: We used to take the finer grades of rock, and grind it extra fine like flour, send it over to Chicago in tight barrels, and they would make it over into white lead paints.

MR. SEARS: In 1876, I visited the State of Missouri, and near Iron Mountain I saw them picking up stone, very small pieces, about the size of my hat, and I asked what it was for. They replied that they took it up to St. Louis, where it was pulverized and used as white lead.

On the same trip I saw a car loaded with something similar. I said to some one, what do you do with this? "We are grinding it up and using it to adulterate white lead."

Later I saw another factory, the same stone and the same process going on. I said to this gentleman, you are not in a legitimate business, you should be arrested and sent to prison. "All right" he replied, "We are making money just the same." From that day to this, I haven't seen any honest lead. I have not found any in twenty years. It is impossible to get it.

SEWER BUILDING AT PORT HURON.

F. F. ROGERS.

Port Huron has twenty-three miles of public sewers all built on the combined plan. The greater portion of them find an outlet in Black river, a stagnant stream intersecting the city and flowing into St. Clair river about two miles below Lake Huron. As I do not wish to discuss the efficiency of our system I will say nothing of the wisdom of these locations and outlets. Every visitor to Port Huron in hot weather decides this question instantly.

The main sewers are egg-shaped and made of brick, where sewers of larger diameter than 24 inches are required. The smaller mains and laterals are vitrified sewer pipe. All are made large enough to carry the storm water.

The sewers are supplied with numerous receiving basins of various patterns and made of iron, stone, brick, and wood. The brick and wood basins are entirely without traps and afford abundant ventilation, but have never been considered offensive. No trouble arises from these basins except in sandy portions of the city, where they have frequently filled with sand above the outlets and allowed a portion to enter the sewers. A few sewers in sandy districts are partially filled with sand from this cause. The remedy suggested and now acted upon is to reduce the number of basins in these localities to the minimum and where used to have them built with silt receptacles unusually deep, and clean them after every heavy storm. I would prefer to abandon the catch basins altogether in sandy districts, but the people frequently ask for sewers more for the purpose of getting rid of storm water than for removing sewage proper.

The town is comparatively flat and many sewers have been laid with grades that will give a velocity of from only two to two and one-half feet per second. Many of these sewers prior

to 1893 were laid with little or no inspection, after the stakes were set and grades given. A custom had been in practice for about twenty years of keeping the grade with a carpenter's level on which a set screw was adjusted to give the proper incline. The stakes were used simply for a check. On sewers with heavy grades this did not prove very bad, but I found that pipes were often out of grade from two to three inches in twenty-five feet. I began to devise a plan by which an ordinary politically appointed sewer inspector with some common sense could accurately keep the grade in the absence of an engineer. Our city has never allowed sufficient engineering help to admit of a man capable of taking levels being constantly on the work, and I suspect there are many other small cities, doing sewer work piecemeal, that attempt to be equally saving.

Our present plan of work briefly outlined is this: Before the bids are called for a preliminary survey is made, taking levels each 50 feet and at all abrupt changes in surface along the entire line of proposed sewer. A profile is made on tracing profile paper, showing cuts at each 50 feet, average cuttings, and any other information that can be shown.

A plan is made showing location of sewer and all apurtenances on tracing paper and on same horizontal scale as profile and the two printed on a single piece of blue print paper. These are made for use of intending bidders and should contain such information as they need.

When the contractor is ready to begin work the line of the sewer is run and marked by stakes and hubs twenty-five feet apart on an offset line, from four to six feet according to nature of soil and depth of proposed trench. The true line is carefully located at each end and the station and "plus" noted at each street intersection, and other permanent objects.

The levels, referred to the city datum, are now taken on the hubs already set. From these levels, cuttings are carried out in the level book in the ordinary way reserving one column beyond the "cuts" for "line heights." In this are shown the

convenient heights above each hub that a line can be stretched giving equal measurements above the established grade, or invert of the sewer. Thus if the sewer is from eight to nine feet deep, the cuts are successively subtracted from 12 feet to get the hight of line at each station in order to use a 12 feet pole.

For the outfit procure two cross-bars and four standards made as follows: The standards shall be of inch hard wood boards, six inches wide, six feet long, sharpened at the foot for driving, banded at the top with a thin iron band about one inch wide and slotted with a one-half inch slot from within six inches of the top to within eighteen inches of the bottom. The cross bars should be from ten to fourteen feet long, to suit the trench, six inches wide and one inch thick and cut from white pine. A one-half inch hole should be bored six inches from one end and a one-half inch slot two feet long extending to within six inches of opposite end. Get four three-eighths inches by three inch bolts, provided with two washers for each bolt. At station "zero" drive one standard, and on the opposite side of the trench drive another. By means of the bolts, a wrench and a carpenter's level adjust the cross-bar on standards to the exact hight shown in the "line hight" column opposite "zero" in the level book. Go to station "one" and set the next pair of standards and cross-bar in a similar manner and stretch a line from the top of the cross-bars at the proper distance from the line of stakes for the center line of sewers. The line will now be the required height above the grade line of the sewer and parallel thereto. (It is better to use three sets of standards as it gives a constant check on all mistakes.) Have a measuring pole provided with a right angle shoe for reaching into the invert of the sewer, and the outfit is complete.

In addition to the work of grading the inspector is required to keep a record of the location of all connections and other fixtures. It is done in this manner. He is provided with a small book in which he enters his records in the manner shown by the following table:

Inspector's Record.

Sta.	+	Left.	Right.	M. H.	Cut.	L. H.	Remarks.
0	----	------	------	----	10.00	2.00	For 12 feet pole.
1	10	6-Y	------	------	9.70	2.30	0 = man-hole at int. of Butler and Fort sts.
2	6	------	6-Y	------	9.60	2.40	
3	7	6-Y	------	------	9.65	2.35	
4	11	------	6-Y	------	------	------	
5	----	------	------	------	------	------	
6	----	------	------	------	------	------	
7	----	------	------	------	------	------	
8	----	------	------	------	------	------	
9	----	------	------	------	------	------	

Permanent records for office reference are then made from the field book and inspector's record books, which are also filed in engineer's office. These maps are made on muslin backed paper 18x36 inches in size, and filed in suitable books, about 10 maps to each book.

The maps are made with the plan on the lower part of sheet and the profile projected vertically above, thus showing the exact depth of sewer at any desired point by a glance. The plan shows location of sewer, connections, man holes, catch basins lamp holes, and any other fixtures, by indicating the station and "plus."

Records thus kept will save the engineer much annoyance and the public will soon learn to call when any information about sewers is needed.

MR. ROGERS: I don't know but I ought to say that the odor there has been very disagreeable for several years, but it is not entirely due to the sewerage. There are fibre works, which pour a considerable quantity of sulphuric acid in the river, and the action of this acid on the impurities in the river, adds largely to the odor. It was very bad for a long time this last summer,

but as soon as the fibre works shut down the odor ceased, though there was as much sewage in the river as before.

THE PRESIDENT: Gentlemen, you have heard Mr. Roger's paper, are there any remarks?

COL. MUENSCHER: My own custom is to drive a pair of stakes on either side. I set the pairs of stakes twenty-five or thirty feet apart, and stake out about 150 feet at a time, that giving five or six sets.

Mark on each set the proper height above the grade, without any reference to the ground. Suppose I have the lower set marked at twelve feet above the grade of the sewer, and the sewer rises three feet in a hundred feet. I put the next set the proper height above, just marking with a pencil then nail on a board, straight edge across the whole set. Then look to see that they are all of the proper grade. Then stretch a cord over the center line, across the top of the cross-bars.

MR. SEARS: Are these boards parallel with the grade line?

COL. MUENSCHER: You drive a pair of stakes on each side. Mark the height of the grade and nail the board across, straight edge horizontally, and then, twenty-five feet beyond, put another set. They are the same height. Sometimes you will have to change the height and mark two sets if the cut is getting deeper. One place you can set the marks ten, and beyond 12, and further on 14 feet, whatever the cut happened to be. By having several sets you will look over the top of the straight edges and see whether you have your grade correct, and not make any mistakes.

MR. ROGERS: I frequently use the method suggested by Col. Muenscher and I think this other is less work than his. It is very quickly done. It only necessitates carrying out one column of figures, beyond what we have to have. It insures accuracy. If I could be on the trench nearly all the time I could get along with almost any method.

MR. APPLETON: I didn't understand Mr. Roger's method I guess.

MR. ROGERS: If you make a profile of the sewer, you put whatever the fill is. If it is three-fifths, two-tenths, or five-tenths that shows on the profile you have with you. After slipping the target on the rod, up or down, that is all there is to it, and by marking underneath, two or three men will set 100 rods of sewer, I was going to say in an hour.

MR. APPLETON: I should think there would not be a very good chance of that remaining in just that position.

MR. ROGERS: These slats are not set at all when the preliminary survey is made. These slats are not used more than 150 feet in advance of the work. When we locate the work, we do as much as we conveniently can, and then turn around and set as many standards as we want to, and when it is necessary to shift one at zero, just move it ahead. If there is anything wrong on stake 4 it is seen instantly.

COL. MUENSCHER: Why set any slats at all?

MR. ROGERS: Those slats are driven at the surface of the ground, and my experience has been that they have not been disturbed very much. Sometimes they will be disturbed by the trench in unstable ground caving in. Of course we have to watch them.

MR. APPLETON: I have found quite frequently that it is often desirable to let your sewer be dug three or four feet before the cross-bars are put on. The cross-bars are often in the way of the pick.

MR. REDMAN: The method which we have employed in Grand Rapids for the last three or four years is not materially different from that spoken of by either of the gentlemen, except that we have not put up the standards across the sewer. The principal reason for this is that we have had so much work on our hands that the two parties in the field could not attend to the work, and do it in that shape. We have put in slats as spoken of at a distance of four to five feet from the center of the sewer. If the grade is very steep, I would put them not more than twenty-five feet apart, but if the grade was very flat

I would try and get them closer than that, because we have found that the majority of inspectors have not put the tile very correctly to grade at long distances. The inspector is supposed to measure from marks put on the stakes. The stakes are supposed to be protected by pipe, and if any of the stakes are removed, we are called upon the ground to reset them if necessary.

MR. ROGERS: How does the pipe layer calculate his grade between stakes?

MR. REDMAN: He puts a plank across the trench and levels it with the spirit level.

MR. ROGERS: That leaves the line at the surface of the ground. Isn't that in the way of throwing the earth out?

MR. REDMAN: The earth is all on one side.

MR. APPLETON: Do you lay your pipes by sighting across from one cross-bar to another, or do you put a fine linen twine across?

A. A string is drawn across; a carpenter's string.

MR. ROGERS: I knew of a contractor employing a fine wire, and it proved to be very good indeed. I employ that now myself.

THE MINERAL RESOURCES OF NORTH ARKANSAS.

E. L. HAYES.

The territory to which I would direct your attention, and through you the attention of the capitalist and investor as well as the prospector and civil and mining engineer is, geographically speaking, comprised in the eight counties of Boon, Marion, Baxter, Independence, Cleburn, Stone, Searcy and Newton. Extending from the Missouri state line on the north to the Boston mountains on the south, and between the ninety-second and ninety-third degrees of longitude west from Greenwich lies the heart of this wonderful region of which I write; a country as little known to the great outside world as is the heart of Africa, so remote from railroads that many of its oldest inhabitants have never even seen one. When some of the aforesaid oldest were discussing the subject of a projected line through this region in answer to the question of, "What is a railroad?" the oracle of the assembly gave it as his opinion that he "jist didn't know, but it must be a rale good road somewhat better nor a pike."

Air lines are common in the older states of the north but it has remained for certain promotors from the cyclone areas to project various wind lines through our country which if carried on to completion will indeed make the wilderness blossom with towns and cities and industries where such things are now but little dreamed of.

Surrounding this part of the state and about equidistant from the center are the Iron mountain branch of the Missouri Pacific railroad on the east, with Batesville the nearest city and shipping point. South of the Boston mountains and paralleling the Arkansas river runs the politically famous Little Rock and Fort Smith railroad, but owing to the mountains it is not generally accessible. On the west is the St. Louis and San

Francisco railroad with, Eureka Springs the nearest city and shipping point.

On the north and completing the circuit, runs the Kansas City, Springfield and Memphis railroad with West Plains, Mo., as the outfitting and business point. These lines enclose a territory some two hundred miles east and west by one hundred and fifty north and south. An empire in itself, and greater in extent and natural resources than many a rich and populous kingdom, or state, of the older civilization.

The counties to which I shall invite your special attention occupy the central part, the heart, as it were, of this immense region, untrammeled by iron bands and dependent for transportation entirely upon the waters of White river or wagon to the nearest railroad. This, in a nutshell, explains the reason why our valuable but weighty treasures can not compete and are comparatively unknown in the markets of the outside world.

Having fixed in mind the country to be explored, the most feasible route to reach it will be next in order. Batesville, the nearest railroad point, is on a branch of the Iron Mountain line, 280 miles from St. Louis. It is also on White river, and if one is so fortunate as to find a navigable stage of water the hardships of travel will be reduced to a minimum, and you will have a delightful steamboat trip up one of the most beautiful of rivers, which for picturesque scenery is unsurpassed, and in fact is often called by travelers the "Hudson of the southwest.". And during the season of navigation, which usually lasts from six to nine months, is worthy the attention of the tourist and sportsman, as well as the prospector and miner, the capitalist or home seeker, all of whom will find something here to interest and instruct them.

When the river is low West Plains, Mo., is the best point to start from, and the trip must be made by horse power instead of steam.

Near Batesville will be found extensive deposits of manganese, which is used in the manufacture of steel.

The Keystone Mining Company operate and control the most valuable of these deposits, and have shipping facilities from Cushman, the terminus of the railroad. Manganese is mixed with iron ores in the making of steel and is used to a limited extent in the arts and sciences. To quote from W. Albert Chapman on the subject, we will say it can be used in the manufacture of chlorine, manganiferous salts, disinfecting fluids, paints, etc. Here a virgin field offers in which is every opportunity for the rapid acquisition of wealth.

Proceeding up the river, the first mountain of note is locally known as "Penter's Bluff," of which T. C. Hopkins in his report on marbles and other limestones, says:

"This bluff is adjacent to good steamboat landings which can be reached by good sized boats the whole year round. The St. Clair limestone, or marble, is exposed immediately below the chert in the more than average thickness of one hundred and fifty-five feet, and except superficially has not suffered from decomposing influences." Here the marble is underlaid by some 250 feet of the Izard limestone extending to the level of the river. On the opposite side of the river and just above, owing to what is known in mining parlance as a fault, the marble comes to very near the waters edge, where boats or barges may be loaded at almost any season of the year. This locality is well adapted as a point for quarrying and shipping this marble, and for the manufacture of lime. Undeveloped at present and only waiting the touch of the capitalist and quarryman to become valuable and productive properties.

This point is about twenty-five miles above Batesville, and here begins the mountain scenery; the fertile, alluvial bottoms become narrower and the river is lined with cliffs resembling the palisades of the Hudson. These ledges are composed mostly of limestones, the marble occuring at certain altitudes and in certain localities only. Where the formations are traversed by ravines the marble juts out as cliffs, and if accessible to water transportation may be quarried and shipped at a nominal cost. The extreme beauty of the red variety thickly set

with snow white crinoids which in cutting assume all manner of geometrical and alphabetical forms and shapes, produces a striking and peculiar effect. Gray, pink and bluish gray marbles also occur. In quality the finer grades equal the marbles of Tennessee or Georgia, and must soon command the attention of the workers in marble and ornamental building stones. Alabaster and onyx are also found within easy reach of water transportation. I have perhaps lingered too long upon the subject of marble, but from its vast quantity, its fine quality and nearness to market, I believe it must soon become one of our most valuable resources.

One hundred miles above Batesville we reach Buffalo City, situated at the foot of the Buffalo shoals, and just above the mouth of Buffalo river. This is the virtual head of low water navigation on White river, and seems destined to become a most important shipping and commercial point, being in the heart of the most productive zinc mining region and almost the only one which presents actual and practical transportation facilities at the present time. It is but eight miles to the famous "Morning Star" mine from which was sent the world beating jumbo chunk of carbonate of zinc weighing 12,700 pounds, which carried off all the honors, and the highest awards both for quality and quantity at the World's Fair, and now triumphantly reposes in the Field Columbian Museum in Jackson park, proclaiming to the world at large that Marion county is the domain of the zinc king, and the Morning Star mine his throne. An English capitalist who recently visited this mine in the interest of a railroad syndicate, said he could not call it a mine for it was a quarry of zinc, and the greatest deposit in the world, more valuable in his estimation than any two silver mines he knew of.

In company with Dr. Carl Rominger, ex-State geologist of Michigan, the writer of this article visited this mine in the summer of 1893, and in answer to an inquiry as to what lay below the immense deposit of carbonates, he said "An equally extensive deposit of blende;" developments since then go to prove the truth of the doctor's assertion.

With 600 tons of free shipping ore on the dump and 250,000 more in sight, can any sane person doubt the value of our zinc deposits? I say more of this mine because more has been done in the way of development work than at any other place. Work is being done on the "Lion Hill," a fine property two miles from Buffalo City. A large crushing plant with steam gigs, etc., is to be set up and put in operation in the near future and it is confidently predicted that this property will develop into another Morning Star. Further on up Marion's creek and five miles from Buffalo City we find the Cane Spring property operated by Mr. Kellogg, of Kansas, who has some fine ore on the platform at Buffalo City ready for shipment.

Just above this property is the Princeton company with a shaft some 80 feet deep, showing good mineral and active mining operations will be commenced in the spring.

Two or three miles south of Buffalo City we find the Cow creek district with promising prospects at the Bonanza, Drybone, Prince Fred, the Fox Den and other claims, where more or less work has been done and some ore shipped Here a good location for a crushing plant presents itself with plenty of ore in sight and liberal inducements would be extended to the right parties to set up a custom crusher. There are other camps and districts in Marion and Baxter, Newton and Searcey counties where zinc is found and with the advent of railroads will be of equal value to those I have described, which are not, however, dependent upon railroad transportation, having the waters of White river for present use and an equal prospect for railroads. As to the character and quality of our zinc, assays show it to be of the best known. We have Smithsonite (carbonate of zinc), calamine (silicate of zinc), hydrozincite, "Marionate" Brannerite, sphalerite (zinc blend, jack, sulphide of zinc, etc.), almost every known variety. I fear I have already exceeded the limits and can briefly mention our other mineral resources, all of which can be found in paying qualities, such as lead, copper, tripoli, kaolin, nitre earths, and various others more or less valuable but dependent upon

improved methods of transportation. We have caves of saltpeter and bat caves containing deposits of guano equal in value to the Peruvian article. There are many very extensive caverns extending for miles in some instances, though never fully explored, and I have no dqubt but what we can rival the famed Mammoth cave or the caverns of Luray if it became necessary. In addition to our mineral resources we have timber and fruit lands, free range for cattle, and mast for hogs, springs of water for the healing of the nations, the finest climate, take the year through, of any portion of the world, a people hospitable and willing to share their good things with all comers who are disposed to settle among us and become useful citizens.

Already the tide of immigration has turned this way, and with the advent of better times, this part of our country is destined to astonish the world. In closing this hurriedly written article I can do no better than to call to your attention the advice of Chauncey Depew, young man, go south.

THE AUSTIN MASONRY DAM, AUSTIN, TEXAS.

E. W. GROVES, ENGINEER IN CHARGE OF CONSTRUCTION.

The surveys for this work were started in May, 1890, the contract awarded the following October and the work of excavation immediately commenced.

The design adopted was for a dam sixty feet high above low water level, having both up-stream and down-stream faces, constructed of cut granite; the interior constructed of limestone of good quality, weighing not less than one hundred and fifty pounds per cubic foot; all to be laid in Portland cement mortar in proportion of one part cement to three parts sand; all stones to be well bedded and all interstices filled. In plan, this dam is straight and resists the pressure of the water by its own weight. In section the up-stream face is vertical, the down-stream face is ogee, the top being curved to a radius of twenty feet and tangent to a horizontal plane and also tangent to a portion of the down-stream face which batters 3:8. At a point forty feet below the crest the masonry begins to curve to a radius of thirty-one feet and broadens until the masonry becomes sixty-six feet wide. This lower curve is tangent to low water level and also to the portion that batters 3:8.

This dam was originally designed with a flat top eighteen feet wide, with the down-stream edge slightly rounded; but the board having the work in charge believed that an ogee form was to be preferred and the change was made regardless of the opinion of the chief engineer, supported by some of the best engineers in this country.

No experimental data exist so far as I know bearing on the proper profile of an overflow dam. Who can even approximate the curve formed by a particle of water in a stream ten feet deep and 1,100 feet long, plunging over a wall of masonry thirty-five to forty feet high into twenty-five feet of water?

Such a stream will create a partial vacuum, between the face of the masonry and the sheet of water and the atmospheric pressure on the outside, will cause the sheet to cling more or less closely to the wall, depending on the vacuum obtained and the parabola we might expect will become something else.

The Colorado river across which this dam was built drains a territory of about 40,000 square miles and is subject to excessive rises in short periods of time. I have seen the stream rise twenty-two and one-half feet in one hour and recede two and one-half feet an hour.

To handle the large quantity of material required and not have the work delayed after the water had subsided by having trestles, tracks, etc., washed away, it was decided to use an overhead cableway, designed by the Ligerwood Manufacturing Company of New York. A great advantage of the cableway system is that when the plant is put in place it need not be moved or altered until the work is done. The frequent changes of position required where an ordinary contractor's plant is used for moving material on such works increases largely the expense and time required. Another advantage of the cableway is found in the fact that it is entirely clear of the work itself and is safe from injury by flood or fire or by explosions on the work below. No less than ten times the work was interrupted by high water, and had the common plan of extending a railway along the dam been adopted these delays would have been greatly lengthened by the time required in replacing portions of track, etc, washed away.

From the natural conformation of the ground, this was an ideal place for the location of this piece of machinery. The west bluff rises nearly vertical to a height of sixty-five feet above the crest of the dam, while the east bluff rises about fifteen feet above the crest. The main cable, two and one-half inches in diameter, was suspended on two towers, the easterly one in which was situated the hoisting machinery, being seventy feet high and the westerly one thirty feet high. Distance between towers 1,350 feet and total length of cable 1,850 feet.

At the time, this was the longest span cableway in existence. On the west side of the river and 1,200 feet up-stream from the dam, was situated a limestone quarry, from which extended a gravity railroad along the west bluff, directly under the cable. A carload of rock could be run from the quarry directly under the cable, taken up at once and transported to derricks on any portion of the work. A double track was used near the dam so that an empty car could be ready to receive an empty skip and a load of rock be ready for transportation. This gravity road was submerged as soon as the dam was raised five feet above low water and recourse was then had to barges, carrying twenty cubic yards of rock which was brought alongside of the dam and unloaded.

Under the cable at the east end, extended the railroad that brought the granite from the quarries, which could be taken from the cars and transported to any portion of the work, in the same manner as the limestone. Mortar was mixed on the wall near the workmen, sand and cement being carried out on the cable. Loads of about five tons were usually carried. This cable was capable of supplying about 180 cubic yards of material, where the distance traveled was not more than 1,000 feet.

During the laying of the foundation considerable water was encountered, the excavation in places being carried eleven feet below low water in the river to get to solid rock. Two six-inch discharge centrifugal pumps were used to keep the foundation dry, but in places where it was impossible to get the foundation in condition to bed stones properly concrete was used to lead up above the water.

Strong flowing springs were encountered in various parts of the foundation, which gave considerable trouble until wrought iron pipe was made use of. The water from the springs was conducted to the pumps through pipes of suitable size, the pipes being covered with masonry and the spring surmounted by a wall of masonry, well built. After the mortar had thoroughly set this well would be filled with rich concrete and no

more trouble would be experienced with that spring. The end of the pipe was stopped with a plug or cap. A gap was left in the dam about 500 feet from the east end fifty feet wide and four and one-half feet above low water, and through this the river was turned by means of a cofferdam constructed of limestone and earth. When this was accomplished masonry was laid in the channel of the river. Near the west bluff three thirty-six inch cast iron pipes were placed thirteen and one-half feet above low water, with valves set in the dam twelve feet from the up-stream face. A chamber 4x6x15 feet, with man-hole to top of the dam gives access to these valves. The pipes not having sufficient capacity to carry the entire flow of the river, gaps were left in the dam, with a difference of elevation of about twelve feet and these were closed with heavy timber gates, supported on a sill of granite at the bottom which proected twenty-four inches from the face of the wall, and rested against upright posts fitted to the face of the dam.

The dam proper was completed in May, 1893. Scarcely a wet spot could be detected on the lower face, except at the toe, where the masonry was not over four feet thick in places, the water probably coming up from the foundation. A few days after completion water began to flow over the crest and to all appearances nothing short of an upheaval of the earth could damage the structure, but one day in the early part of June a small stream of water was seen to issue from a soft stratum of rock, which formed the east wall of the turbine room, 100 feet down stream from the dam and forty feet below the level of the top of the dam, and in less than two hours the head gate masonry had been undermined and thirty feet of it settled two feet, the power house foundation was overturned and much other damage done, entailing a loss of about $100,000. The headgate masonry which was a continuation of the east end of the dam, was built under the direct supervision of the mayor of the city, by resolution of the board of public works, and being anxious to demonstrate the uselessness of excavating a large amount of soft material he joined the headgate masonry to

material little better than ashes which it strongly resembled with results as stated. Being absent from the city when the break occurred, I was called back by telegram and placed in charge of repairing the work under plans suggested by the consulting engineer. However, in a short time, the mayor wished to experiment with his methods of construction, and being unwilling to adopt his ideas I resigned in July, 1893.

The following table gives figures of principal interest concerning the dam and water power:

Length of spillway	1,090	feet
Length of dam, including bulkheads, etc.	1,275	"
Height above low water	60	"
" " foundation	68	"
Width at base	66	"
Horse power (for 60 hours per week)	14,500	
Minimum flow (cu. ft. per sec.)	750	cu. feet
Maximum flow	250,000	" "
Drainage area	40,000	sq. miles
Area of lake formed	2,000	acres
Masonry in dam (except head gates)	90,628	cu. yds.
Maximum size of rubber	5	" "
" " " granite	93⅓	cu. feet
Paid contractor for dam alone about		$611,000 00

A granite faced revetment wall on the easterly bluff forms a retaining wall for a distance of 260 feet down stream from the toe of the dam and forms the west wall of the power house The east wall rests on the ledge of the cliff, forty-four feet above low water. At the easterly end of the dam water will be taken through seven to nine feet penstocks and conducted to the turbines whose foundations are fifteen feet above low water level. There are to be four pairs of horizontal turbines of 506 horse power each, under fifty feet head, each pair discharging into a common draft tube. On each shaft will be two pulleys, from which belts will lead to the dynamo. There will also be two vertical turbines, each of 200 horse power under fifty-four feet head, each shaft to be connected with a pump by means of bevel gear. It is intended to supply the city with

water and electric lights, furnish power for street car purposes and manufactuirng. The work is not yet completed, but probably will be within six months. The approximate cost of the work compete was $1,400,000, but this will not be sufficient to complete the work contemplated at the outset.

SOME NOTES ON HIGHWAY GRADES.

BY JOHN RANDALL.

In determining the character of the grades admissible on any road one of the things of prime importance is to thoroughly understand the motive power to be used thereon. In these days of railway building about the only power ever thoroughly discussed in this connection is the locomotive. The iron horse has but one pair of muscles and practically they never get tired. It can exert its maximum tractive force upon the rail as long as the fuel and water lasts. On all roads except railways the prevailing motive power is animal. Even the bicycle—except, of course, when ridden by a lady—is propelled by animal power. The horse has more muscles than a locomotive, and to successfully accomplish the greatest amount of labor he cannot be limited to the use of a single set of muscles nor can he use these continuously anywhere near to their maximum capacity. The complex structure of an animal does not render possible an exact analysis of his movements as is the case with the locomotive, yet a few general observations will be useful. See the horse when pulling a load. Notice the variations in the mechanism of his step as his load changes from light to moderate, then increases to a sharp pull. Then as the summit is reached and the traces slack he takes a long breath of pride and satisfaction and with a still different step walks contentedly down the slope gathering strength for the next pull which he attacks eagerly and conquers with unmistakable pleasure. On the race track he must not be urged to do his best in the first quarter or he will lose. If, instead, the animal were required to pull a load up a difficult hill where the amount of the load and not time were the important object it would be best to attack the steepest part near the beginning

and make the work easier at the last, but the fact remains that a varying effort of the animal within rather wide limits seems best for the accomplishment of the greatest amount of work. While riding over long level reaches of country the wheelman sometimes changes the throw of his pedals in order to give his muscles the necessary change of action and working position which the animal economy imperatively requires, in order to easily accomplish its maximum amount of labor. Men of judgment and experience in handling teams maintain that it does a horse good to take a sharp pull occasionally. It quickens the circulation and expands the lungs and the writer has seen horses that really enjoy such an effort as well as some men enjoy a friendly scuffle, provided, of course, they are victorious. A pair of horses will put a street car in motion from a stop almost as expeditiously as a twenty-five horse power motor can do it, but could not exert such an enormous tractive force continuously. Yet by this varying and intermittent effort the street car horse is enabled to perform many horse power hours of work per hour.

From these rather rambling remarks on the character of animal motive power I do not propose to make good the often absurd claims of many teamsters in favor of undulating grades, but hope to show that within some limit rise and fall is certainly innocuous while there is a strong probability that it may be beneficial.

INNOCUOUS RISE AND FALL.

In railway work the elimination of rise and fall is not thought so important as formerly and Mr. Wellington in his admirable work, "The economic theory of railway location," shows by clear demonstration that as a general rule a sag of twenty feet in vertical depth from the main grade line with a proper vertical curve in the hollow is practically innocuous in its effect on the motive power. In practice the train is usually assisted out of the hollow by the momentum acquired through the higher velocity in running into it, but it is easy to see that

if it were practicable to keep the speed uniform by using no steam going down and twice the normal amount of steam going up, the effect would be the same provided no power were wasted at the brake shoes.

We next inquire what rate of grade would be thus innocuous on a common road, provided it does not injuriously limit the load that can be hauled over it. This is nothing more nor less than the grade of repose of the loaded vehicle at the ordinary velocity of team travel and depends on the character of the road surface. The experiments of Morin on the tractive force in terms of the load required on a level for various road surfaces can be very easily translated into the grade down which the load would move by its own gravity without being held back by brakes and without acceleration of speed. For broken stone roads a little moist or dusty, it is as follows:

Kind of vehicle.	Fraction of load required.	Grade of repose in feet per 100.
4-wheel truck, 3 or 4 horse	1-38th.	2.63
4-horse coach on springs,		
Walk	1-34th.	2.94
Trot	1-27th.	3.70
2-horse carriage on springs,		
Walk	1-34th.	2.94
Trot	1-27th.	3.70

On gravel roads, properly compacted by using the least amount of binding material and plenty of brains, the rolling friction would be very nearly the same. Experiments by the writer upon loaded wagons with three-inch tires on a tolerably hard and smooth gravel road in fair condition place this grade a little above two and one-half per cent.* These experiments of the writer were very simple and consisted in ascertaining by a judicious average of repeated trials, the lowest point on an easy vertical curve at which the load would just move by the horizontal component of is own gravity.

* On sand, not deep but a rather bad sandy road, this grade was found to be a little above 12 per cent, showing that on such a road four-fifths of the animal's labor is wasted, not taking into account the further waste of energy occasioned by bad footing.

Finding that down grades not exceeding two and one-half per cent do not require any power to be wasted in holding back, we concluded that they have no effect, except probably a beneficial one as heretofore noted, and therefore we should not spend the corporation's money in an effort to further reduce them provided they are not of the class which we will now consider, namely.

LIMITING GRADES.

The usefulness of a long piece of good road is often limited by the load that can be pulled over a single bad hill. Yet its location has some effect in determining the expense we may incur in getting around or through it. On a road twenty miles long leading into a market town we might, generally speaking, incur three times the expense in removing any obstacle to traffic five miles out than would be warrantable in the same work fifteen miles out of town. But if the limiting grade five miles away cannot be eliminated, it would manifestly be a waste of capital to expend a large amount of money further away in reducing the grade at another bad hill below the limiting rate.

Experience has shown that storm water is liable to seriously injure a roadbed built on a grade higher than five per cent. It is not believed a first-class highway ever need exceed that rate. Railroads are carried almost anywhere except in mountain regions on maximum grades of one per cent and a highway can be easily located with maximum grades of five per cent or even less provided the desirability of such a road is known and appreciated.

But it is the writer's opinion, based on a considerable amount of observation and experience in hauling freight on bad roads that an occasional five per cent grade with a good road surface would not limit much below eighty hundred weight the load that could be hauled by a pair of draft horses. Further, it seems as if on most country roads it would be best to discourage loads greater than, say one ton per wheel. This

might make lighter and less expensive construction possible, or at least there would not be so much danger of having the road damaged by an excessive load at a critical time when the frost is coming out. The cost of good road construction is in many localities prohibitive and any fairly economical method of reducing this is fraught with grand possibilities.

Early English road authorities considered it proper in ascending a hill to decrease the grade toward the top. We would go farther than this and make the steepest part directly at the bottom and thus give the team a chance to surmount a considerable portion of the elevation while fresh, instead of easing off the grade at both top and bottom as is the usual practice. In moderately level or slightly rolling country this is the natural contour of the surface. The round elevations usually meet the flats rather abruptly, making an ideal gradient and rendering it unnecessary in many cases to deface the fair form of nature with stiff looking cuts and embankments that never pay dividends.

While it is more important that the road shall be suited to team travel, especially of loaded teams, let us see how this style of grade would suit the bicycle rider, for when this road is built the farmer boys will have wheels, and possibly learn to enjoy life at home the same as their city cousins. The wheelman takes a run at the hill. A swish and a flash and he is up where it is easy climbing, carried there by his own momentum, greatly aided in this case by the rotative energy stored in the comparatively heavy tires and rims. Were the rise longer and more gentle at the start this momentum would be largely used up in overcoming air resistance, and rolling friction which is a considerable item in comparison with the limited power that can be delivered at the pedals.

In surmounting a long, gradual rise earthwork can be generally saved and the road better adapted to animal traction by breaking it up into sections of a slightly higher rate interspersed with short places nearly level. Long, continuous grades in one direction should be avoided for other reasons.

Ruts should not be allowed to form on a good road, but the fact is that they usually are allowed, and storm water often needlessly follows these ruts thousands of feet on its mission of destruction. It is needless to say that this furnishes another reason why vertical angles should be rather abrupt in sags. Vertical curves are desirable over summits, but out of place in the hollows.

IN CONCLUSION.

The young engineer in taking up this class of work is admonished to discard some ideals which may have been a proper guide in railway or city work, keeping in special prominence the hard, uncompromising condition or question of dollars return for the outlay of the taxpayers along the line by enabling them to move paying loads with economy. The light vehicles moved for either pleasure or profit will get along very nicely if the first condition, this world-moving question of dollars, is properly met, and then everybody, even the bicycle girl, will be pleased.

The writer is aware that in this paper he has said nothing new, and probably with one exception nothing but that which has heretofore been accepted in the profession. That exception is the old and supposedly exploded theory that a hilly road is better than a level one, which theory he audaciously assumes to be worthy of serious consideration. He is also aware that in following new paths with something of the fervor of an enthusiast, it is difficult for a person to estimate the value of the "personal equation," and cherished theories often assume undue prominence, but if these crude notes and suggestions may attract other and better disciplined minds to this seemingly inviting field, he will be content.

LOGGING RAILROADS.

H. C. THOMPSON.

I shall only attempt to draw your attention for a few moments to the evolution that has taken place in the past twenty years in the manner of handling large amounts of logs and timber. It is but a few years since the only successful way of transporting these forest products was on sleighs, and as this could not be done only under favorable conditions, such as are incident to cold weather and plenty of snow, the lumberman had to devise other means of transportation when these failed. When the haul was short he used a "dray," as we call it here, made of two runners with a beam across, and with one end of the log dragging on the ground. In the south they use what they call a "lizzard," made out of the crotch of a large tree and hewed down to suitable dimensions, and it is generally drawn by four or five yoke of oxen. From these primitive implements we next come to the log sleigh, which was used when the haul was over one-half mile and from that up to seven or eight miles, the width of the sleighs increasing from year to year, from the ordinary width of road sleighs to nine or ten feet, requiring a road to be graded as smooth and even as the grades are now on some of our logging railroads.

But this means could only be used in cold weather and some substitute had to be adopted.

About the first successful departure from the old way, was the use of poles from six to twelve inches in diameter laid on the ground as rails upon which trucks with wide grooved wheels were hauled with horses. Next a tram road was used consisting of cross ties with stringers or rails of wood, and as the wood soon wore out, flat iron was spiked on top of that and the ordinary flanged wheels were used. But the lumberman found that the timber was becoming scarce and the

distance to banking ground becoming greater, and the locomotive was soon called into service in this branch of industry. Tracts of land before considered of little value and practically inaccessible may be worked more profitably by the use of railroads than others more favorably located in the old way. Now there are many logging railroads in Michigan ten miles in length and several of over one hundred miles, with a capacity of seventy-five thousand feet per train load, running over grades and around curves that an old line engineer would laugh at and would have said twenty years ago that it would have been impossible. Some of the roads use an extra locomotive to make up trains, the one best adapted to sharp curves and steep grades, the wheels of which are driven by bevel gearing attached to the right hand wheels of each truck, each truck being free to adjust itself to curves and irregularities of the track. These engines cannot quite accomplish the task of climbing a tree, but it is surprising to see how they will come up out of some deep ravine with two or three cars loaded with logs. The boys call them "crabs," and the expression "you are liable to meet a crab crawling around the woods anywhere," seems very appropriate.

Ravines or depressions are crossed by constructing trestles built up of logs laid in squares to the required grade, or by timber framed into bents resting on mud sills, if the road has any degree of permanency.

Trestles of logs thirty-five feet high and two thousand feet long, with a grade of three feet per hundred are in use on some Wisconsin narrow gauge roads, and the writer recalls to mind a section of one of these roads one mile in length on which there were no less than twelve of these log trestles from forty to sixty feet high and from one hundred to three hundred feet long. These logging roads thus crawl, snake like, into territory that was inaccessible prior to their advent and the once silent forests resound with the tread of the iron horse, which in conjunction with the steam skidder soon cut a wide swath of destruction among the tall and stately pines.

Much discussion has been had over the merits of narrow and wide gauge. The narrow gauge admits sharper curves, as the wider the gauge, the more slipping of wheels on curves, but practically this is too small to consider unless on curves too sharp to be desirable on either gauge for ordinary purposes, so that there is but little choice between narrow and wide gauge, except as special conditions may exist in each case. A road should be equipped with enough cars for two trains, one to be loading while the other is on the road. The advantages and economy of logging railroads are not confined to large operations, but are just as valuable for any mill of small capacity in hauling logs or lumber over half a mile.

The relative economy increases rapidly with the length of the road. While it is almost impracticable to haul with horses over half a dozen miles, logs can be hauled twice that distance by the locomotive cheaper than by horse two or three miles.

RELATION OF USEFUL WORK TO LOST WORK IN THE PROPELLER WHEEL.

H. C. PEARSONS.

I present you with the discussion of a problem that is not generally understood by those who most want it, at least our manuals, for the mechanical engineer, give us no literature on the subject, though engineers have found the "efficiency" of their machinery in ships, to great precision, by means of the dynamometer.

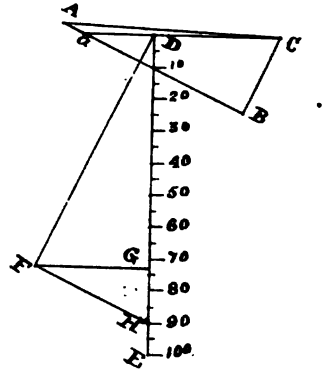
The problem yields readily, both to graphical and to numerical analysis.

I can best illustrate by an

EXAMPLE.

Suppose we have a propeller wheel of, say 12 feet diameter, and 16 feet pitch. It is desired to know what portion of the work expended by the wheel is useful work, and what portion is lost work.

First express the pitch in terms of the diameter as unity, which we will find to be as 1 to $1\frac{1}{3}$.



By any convenient scale, assume 3.14 units, to represent the circumference of a circle to diameter unity, and set the same off in a horizontal line A B—see fig.

This line is supposed to be in a plane that is perpendicular to the shaft that is turned by the wheel.

From B set up B C=$1\frac{1}{3}$ units from the same scale, and perpendicular to A B, and join A C, then will the angle B A C be the pitch angle of the wheel, at the

end of blade. But we want the angle at the center of effort or at the center of percussion of the blade.

The books tell us that this point is at the circumference of a circle whose area is one-half the disc area of the wheel, or at the square root of $\frac{1}{2}$=0.71 the radius of the wheel. But this is a mistake. The disc area of the wheel varies as the square of the radius or length of blade; also the intensity of percussion varies as the square of velocity, and velocity at any point varies as the radius, whence the intensity of percussion varies as radius square.

Again the entire work of the wheel varies as the product of these two factors, or as (radius) 4, whence the center of effort of a blade, whose helix is a true screw, is at a point from the center = the fourth root of $\frac{1}{2}$ = 0.84.

But our wheels are not made a true screw for the full length of blade, but have their pitch for $\frac{1}{4}$ to $\frac{1}{3}$ the length of blade, at the inboard end, reduced to be equal to the net pitch as nearly as may be, for the purpose of throwing the work to outer end of blade, where a better per cent of useful work is obtained.

This throws the center of effort out to about 90% of the length of blade from center of wheel.

Then from B, set off 90% of B A to B*a*, and join *a* C. The angle B *a* C is the angle at the center of effort of blade.

From any point, as D in *a* C, set off D E, perpendicular, and on it set off 100 units to E, from any convenient scale, to represent the total work of engine.

From observation, or partly from observation and partly by estimation, find the per cent of the whole power of the engine, to put the machinery in motion without any load, *i. e.*, to overcome friction and the inertia of the machinery, say 10%.

From E set up this 10% to H, then D H is the part of the power expended by the wheel.

Through D, draw D F, perpendicular to A B, and through H, draw H F, parallel to A B. Then will D F and F H, be two component forces, whose resultant is D H, the part expended by the wheel.

Now we are to divide D H in in G, such that D H is to G H, as $\overline{D F}^2$ to $\overline{F H}^2$.

This is done by drawing through F the perpendicular F G on D E, giving

D G = the useful work

and G H = the lost work

and E H = work in putting machinery in motion.

Though in describing this solution, and the reasons therefor, we have drawn it out to a great length, the work will be found very simple and concise, and the numerical work will be found to be equally simple.

It will be seen that D F is cosine on D H, and D G is cosine on F D, both to the working pitch angle,

whence, $\cos^2$. measures the useful work,

and $\sin^2$. measures the lost work; then

dividing B C by B a, we have

$1.33 \div \overline{3.14 - .31} = 0.47 =$ Tan. working pitch angle $= 25°10'$,

and $\cos^2 25° 10' = 0.8192$,—then $0.8192 \times .90 = \underline{73.72 =}$ useful work.

$\sin^2 25° 10' = 0.1808$,—and $0.1808 \times .90 = \underline{16.28 =}$ lost work.

These = the 90% spent by the wheel, as found by the graphical work.

That part of the work called "lost work," is worse than lost, it is *pernicious* work, it is perfect *torsion*, acting like a paddle wheel turned fore and aft in the vessel. It is this component that wrecks steamers' shafts at sea.

A pitch of $1\frac{1}{2}$ diameters would give of useful work 70.16 per cent and of lost work 19.84 per cent.

From the above, we see that to increase the pitch angle is to increase the pernicious work at the expense of useful work, thus requiring a greater shaft for the smaller thrust.

It is but a few years since wheels having from 1½ to 2 diameters for the pitch, were considered in good proportion. Then the efficiency ranged from 55% to 65%. But steam of higher tension, 150 lbs. and over, in place of 40 to 50 lbs., makes higher piston speed possible. This gives better percussion, makes the feather wheel possible, by which the pitch-angle is reduced, thereby saving a better per cent of useful work.

A HARD TRAMP.

F. HODGMAN.

[Read at the social meeting, Wednesday evening.]

In looking over one of my diaries I came across the following entry: "November 10, 1881. Had a team of Haws & Co. to take us over to Fish creek. Walked back over the line a few miles and then struck off across the mountains. Had a devil of a jaunt and was completely tired out and used up."

This entry brings to mind very vividly an occasion when a party of three of whom I was one came very near to perishing with cold and fatigue in the drifting snows and freezing blasts of winter in the Wasatch mountains. I was at that time engineer in charge of construction of a seven mile division of the Rio Grande Western railroad, extending from the pass at Soldier Summit down the west slope along the valley of Soldier Fork to Clear creek station on the U. & P. V. railway. My camp was near the middle of the division right at the base of a mountain which rose with a sharp slope to a height of 3,000 feet or more above the valley. The work of grading on this division was nearly completed. One small party was yet engaged in blasting out the rock in a twenty foot cut at the summit of the pass. The division next to mine on the eastern slope had been in charge of an engineer named Smith, who had been discharged for collusion with the contractors and for returning false estimates of the character and amount of work done. The grading on Smith's division was pretty much finished. One day I got a telegram from the chief engineer ordering me to go over Smith's division as far as Fish creek and report on the bridges and culverts needed. As teamsters were using the grade for a highway I was also to employ some one to cut trenches and put obstructions on the grade in places

where it would be most effective in order to stop travel on it if possible. It was seventeen miles by the grade from my camp to Fish creek and as I had recently had a month's illness I did not feel quite equal to walking the distance both ways so I employed one of the contractors—Haws—to take us over to Fish creek in a spring wagon. Frank Ames and his brother George went with me as assistants and we took our guns with us intending to return by another route and hunt along the way. It was a raw, chilly day and the snow lay deep along the Soldier Fork and on one side of the mountains facing it. It is a curious fact that the greater part of the rain and snowfall is on the west side of the Wasatch mountains, the trend of the range being north and south, and in consequence the greater part of the timber and vegetation is on that side. On the east side there is little rainfall and almost no timber, what there is being for the most part scattering trees of cedar and pinon pine growing in favored spots and scraggly and stunted at that. As we climbed along the west slope the cold wind was at our backs and a few scattering snowflakes were flying sometimes hitting us on the ears or in the face and striking like grains of sand. When we had passed the summit we came into a milder climate. Soldier pass is about 7,500 feet by the aneroid above the level of the sea and the mountains on either side rise from 2,000 to 3,500 feet higher. There was no snow on the east slope and we rode merrily along the grade stopping when necessary to make notes of the location and dimension of the culverts or bridges required. It was past noon when we arrived at Fish creek. We sent the team back and after eating our luncheon started back over the line, moving piles of ties and piling them up on the grade. It may as well be said right here that this work as well as a subsequent trenching of the grade was labor and money wasted, for the teamsters filled the trenches with ties and threw the rest of them down the banks and went on using the grade for a highway the same as before. I think too that the travel on the grade did more good than damage. After following the grade

in this way for about five miles we left it and struck off into the mountains. From the point where we left the grade to our camp the road may be said in a general way to follow the two sides of a triangle with the apex at Soldier Summit. We proposed to take as nearly as we could the line making the third side of the triangle and in so doing would leave Soldier Summit about three miles to the right of us. We had a steep climb up the eastern slope but the ground was bare and we met no difficulty other than the severe labor of mountain climbing. Once or twice we caught sight of moving deer but they were going in such directions that we could not afford to follow them even if we had been sure of getting one. As we neared the top of the range the climbing was not so steep. We found more timber in the ravines and we also found snow. The mountain top was not a sharp peak but a comparatively level plateau cut up in all directions by small valleys and steep ravines hundreds of feet deep, covered with loose snow from eighteen inches to six feet in depth, according to the location. Soon after reaching the top of the mountain we came into a gentle valley well timbered with pine of a size suitable for piles and ties and some good sized sawing timber. Here we found plenty of fresh deer tracks as well as some immensely large tracks of timber wolves. We saw no game except pine and sage hens and we had no time to follow the deer tracks, for it was nearing night and a heavy snow storm had set in with the wind blowing a gale in our faces and the snow so thick we could see but a short distance through it. We were not provided for camping out. It was getting colder every minute as the storm howled fiercer and harder about us and weary as we were we began to realize that it was a question of life or death whether we reached camp or not. We were already thoroughly tired out with the mountain climbing, but the way became every step rougher and more difficult. Then there was the constant danger of getting lost. Not one of us had ever been in that part of the mountains before and we had to guide ourselves on general principles. I had a pocket com-

pass and had estimated the course as nearly as I could, trusting to be able to see camp when we were far enough over the mountains to get a view of the valley of the Soldier Fork. But the snow storm shut that out. Our route was a constant ascent or descent of the steep sides of the deep ravines as we crossed one after another in succession. There were a good many saplings of quaking asp along our pathway, many of them standing dead and denuded of bark and many more lying on the ground under the snow. If we stepped on one of these on the hillside we were almost certain to slip and fall. Sometimes the deep snow saved us from being hurt and sometimes we would strike the sharp point of a hidden rock. We got many a wrench and many a slide down the slope with a mass of snow going down with us. One fall spoiled my compass and we realized more fully than ever before that we *must not* get lost. Keeping two or more objects in range in the direction we were going we pressed wearily on, never daring to swerve aside from the course for any reason lest we lose it. When there were not objects within sight that we could range by, as in going down through a ravine, we would get out in a row in the desired direction and the two forward ones would stand still while the rear one passed to the front and put himself in line. At last just as night was closing in we emerged from the rough timbered region into a smoother and more open tract where there were no trees but only a few small dwarf oaks or aspens here and there. It was lighter here and the snow was not so deep. The snow on the ground was beat down harder and crusted so we did not sink so deeply in it. The falling snow was not so thick and the clouds were broken, but the wind had freer scope and drove the snow more fiercely in our faces. When passing through the timber and the deep ravines, we were warm enough with the severe exercise and moistened our clothing somewhat with perspiration, but when we came out into the open the fierce cold winds chilled us to the marrow. We were now on the western slope and gradually descending.

Occasionally we would get a peep, through the rifts in the clouds, of some well known landmark. Night had come and with it the snow ceased falling and the stars peeped out among the broken, flying clouds. Oh how wearily dragged our limbs along that trackless waste of snow where possibly man never trod before or since. It makes my bones ache yet to think of it. We were not lost. We knew very nearly where we were and when at length we reached the shoulder of the mountain, from which we could overlook the valley of the Soldier Fork, we knew exactly where we were. We had missed our objective point, so instead of taking a straight course for camp we took the shortest cut into the valley, a much easier though longer road. Now and then we would start up a sage hen or a big white mountain hare, which would hop away in the starlight. Wolves were howling back of us in the timber but we cared little for them. They were not likely to meddle with us and if they did we were well prepared for them. Now and then we heard the distant cat like yowl of the mountain lion. As we neared the valley the descent became more and more precipitous and we clambered, slid, rolled, and tumbled in our weakness down the last descent into the valley. There we were, on the grade, near the big spring that boils up beside it near station 80. We were out of the wind down there and it was clear starlight, but darker in the valley than on the mountain. We rested awhile, took a good drink from the big spring, and then, full of hope but *so tired, so tired,* we dragged ourselves along toward camp. It was three miles away but we had been over the ground nearly every day since the middle of August and every slope stake was a familiar old friend. There was no more climbing. It was all down hill, on a smooth finished grade which fell 200 feet to the mile and the change from the mountain work was so great that it fairly seemed to rest us to walk along it. Before we reached camp we were swinging along at a four mile gait and when we got there, the cook had a smoking hot supper awaiting us, of which the principal item was

venison cut in slices as big as your hand from the saddle of a 200 pound deer which *we* did not kill but some one else did. If ever a meal tasted good that did, and if ever sleep and rest were sweet to mortal man they were to us that night as we stretched ourselves out in our blankets, on beds made of spring poles covered with cedar boughs and rabbit brush, and gladly welcomed "tired nature's sweet restorer, balmy sleep."

A QUEER MAN.

F. HODGMAN.

[Read at the social meeting.]

It was a young surveyor
  Lived in a country town,
And went about surveying
  Through all the country round.

He sometimes to the city
  Would take an early train,
And when his day's work ended
  Went straightway home again.

It was an honest Dutchman
  Who owned a city lot,
That with his nearest neighbor
  Had into trouble got.

He said to the surveyor,
  "I vish you come to town,
And mit your shain and compass,
  You run my lot around,

"I dink my nearest neighbor
  He got some of my land;
He says he's going to keep it,
  And dot I'll never shtand.

"Van Eest is mine vrow's fader,
  When you get done mit mine,
Den you shall go to his house
  And measure out his line."

It was the young surveyor
  Ran out the Dutchman's line;
It was the honest Dutchman
  Who took him in to dine,

And when the meal was over,
Who went with him up town,
To where Van Eest and his good wife
Were both at dinner found.

Up spoke Van Eest, "Good day, sir;
Come sit you down and eat."
"No; thank you. At your daughter's
I've had a meal complete."

"Den if you be not hungry,
You'll take some beer, I dink."
"Oh, no; I thank you kindly,
But beer I never drink."

"Vell, now I've done my dinner,
Come have a shmoke mit me."
"I never use tobacco,
And so that cannot be."

Up spoke Van Eest, his good wife,
"You stay to see the sight,
When you are in the city?"
"No; I go home at night."

"I s'pose your little children
Are glad to see you come."
"No, ma'am; I have no children.
My neighbors they have some."

"Dear *man alive! No children!!*
What! Have you got no wife?"
"You've hit my case exactly.
I live a single life."

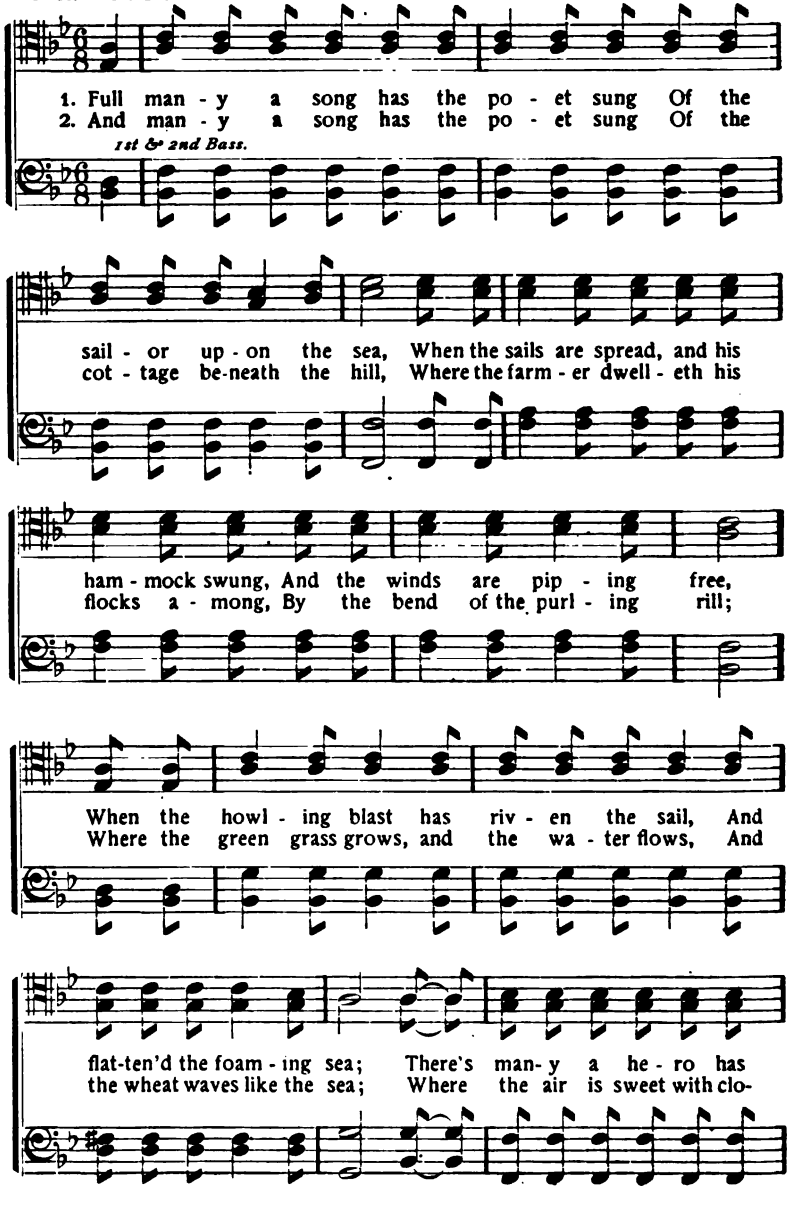
The woman full of wonder,
Her aged hands upraised,
And at that strange surveyor,
In astonishment she gazed.

"You never use tobacco;
You drink no beer mit me;
You got no wife nor childer;
Why! What a man you be!"

WHAT I WOULD BE.

(MALE QUARTETTE.)

F. H. *1st & 2nd Tenor.* F. HODGMAN.


1. Full man - y a song has the po - et sung Of the
2. And man - y a song has the po - et sung Of the
1st & 2nd Bass.
sail - or up - on the sea, When the sails are spread, and his
cot - tage be-neath the hill, Where the farm - er dwell - eth his
ham - mock swung, And the winds are pip - ing free,
flocks a - mong, By the bend of the purl - ing rill;
When the howl - ing blast has riv - en the sail, And
Where the green grass grows, and the wa - ter flows, And
flat-ten'd the foam - ing sea; There's man- y a he - ro has
the wheat waves like the sea; Where the air is sweet with clo-

WHAT I WOULD BE.

brav'd the gale, But nev - er a sail - or I'd be.
ver and rose; Yet nev - er a farm - er I'd be.
CHORUS.
be - - - - - -
But nev - er a sail - or I'd be, But nev-er a sail - or I'd
Yet nev - er a farm - er I'd be, Yet nev-er a farm -er I'd
be - - -
be, No, nev - er a sail - or I'd be, No,
be, No, nev - er a farm - er I'd be, No,
nev - er a sail - or I'd be; Let them fol-low the sail who
nev - er a farm - er I'd be; The clo- ver and rose are
love the gale, But nev - er a sail - or I'd be, I'd be.
sweet to me, But nev - er a farm - er I'd be, I'd be.

WHAT I WOULD BE.

The lawyer may study his musty tomes
For the laws of a thousand years;
The doctor visit the stricken homes
Where sickness or death appears;
The preacher may plead with his fellow man,
And offer salvation free
To win an immortal soul if he can,
But neither of these I 'd be.

Cho.— But neither of these I 'd be,
No, neither of these I 'd be,
For the labor that filleth my heart with cheer
Is the work of the civil engineer.

I 'll follow my craft o'er the world's domain,
By mountain, by river and sea,
And I 'll mark out the lines with my transit and chain
Where the marts of the world shall be.
I will tunnel the hills, and I 'll water the plains;
Full many a track will I build,
Where the cars shall roll in majestic trains,
With the wares of the nations filled.

Cho.— An engineer I 'd be,
An engineer I 'd be,
For the labor that filleth my heart with cheer
Is the work of the civil engineer.

I will bridge the straits, and the rivers I 'll span,
And their beds I will tunnel through,
While the boats shall float in new channels I plan,
From the lakes to the ocean blue.
To the cities I 'll carry the waters sweet,
From the fountains cool and clear;
For the calling for me that is most complete
Is the work of the engineer.

Cho.— The work of the engineer,
The work of the engineer,
The calling that filleth my heart with cheer
Is that of the civil engineer.

LEGAL DECISIONS.

1. Where a street laid out on a town plat is opened up by the owner in a course varying from the lines, and is opened to the public, the description in deeds subsequently made referring to the street as a boundary relates to the street as opened up.—*Winter v. Payne* (*Fla.*), *15 So., 211.*

2. Where owners of land plat the same, and sell lots, with reference to streets laid out on the plat, it is a common-law dedication of the land reserved as streets, though the plat was not acknowledged, as required by Comp. St. 1893, c. 14. § 105.—*Pillsbury v. Alexander* (*Neb.*), *58 N. W., 859.*

3. Where land was platted by the owner, who dedicated to public use all the streets on the plat, whereon it appeared that there was a strip 50 feet wide, the south 30 feet of which were separated by a dotted line, and inscribed, "30 feet reserved for sidewalks, shrubbery, and ornamental purposes," and the strip was afterwards used as a street, the 30-foot strip became a part of the street without restriction by user. —*Dickerson v. City of Detroit* (*Mich.*), *58 N. W., 645.*

4. The non-user of a dedicated street, though extending through the period covered by the statute of limitations applicable in cases of adverse possession, will not constitute an abandonment of the street, as a street can only be abandoned by a proceeding to vacate the same.—*City of Lawrenceburgh v. Wesler* (*Ind. App.*), *37 N. E., 956.*

5. Where land has been conveyed to a village for use as a public burying ground, the village council, in their character as trustees, cannot abandon the use, and thereby defeat the beneficial interest of the public.—*Board Com'rs Mahoning County v. Young* (*C. C. A.*), *50 F., 96.*

6. Where it is shown by uncontradicted evidence that a section corner was located by the government surveyors at a cer-

tain point, such location must control, though it is a place different from that given in the field notes and plat.—*Peterson v. Skjelver* (*Neb.*), *62 N. W., 43.*

7. The original monuments established during a government survey control course and distance.—*Peterson v. Skjelver* (*Neb.*), *62 N. W., 43.*

8. In construing a deed describing land by government survey, the corners of the survey, as actually established, and not as they ought to have been established, are the true corners, notwithstanding their location may not be such as is designated in the plat or field notes. Squire v. Greer, 26 P., 222, 2 Wash. St. 209, modified.—*Greer v. Squire* (*Wash.*), *37 P., 545.*

9. The presumption is that the corners have been established at the places indicated by the field notes, and the burden of proving otherwise is on him who disputes their correctness.—*Greer v. Squire* (*Wash.*), *37 P., 545.*

10. Under Act Cong. Feb. 11, 1805, regulating the location of corners and boundaries of surveys, and providing that boundaries which have not been actually run and marked shall be ascertained by running straight lines from established corners to the opposite corners, and Code, § 373, requiring county surveyors to be governed by the acts of congress and the instructions of the secretary of the interior, the center of a section which has not been fixed by the government survey must be determined by the "intersecting" method, *i. e.*, by running straight lines from the quarter corner on the east to the quarter corner on the west and from the quarter corner on the south to the quarter corner on the north sides of the section, the center being the point of intersection.—*Gerke v. Lucas* (*Iowa*), *60 N. W., 538.*

11. Where it is shown that a section corner was located by the government surveyors at a certain point, such location must control, though it is a place different from that given in the field notes and plats.—*Woods v. West* (*Neb.*), *58 N. W., 938.*

12. Appellant owned the south half, and appellee the north half, of a northwest quarter section. By the original survey and plat of the surveyor general, the east line of the quarter was 38.05 chains, and the west line 38.48 chains; and, while the half-quarter line was not established, the plat assigned 20 chains to the east and west lines of the quarter at the south end, and 18.05 chains to the east line, and 18.48 chains to the west line, at the north end. The east and west lines of the quarter were in fact only 37 chains, so that the quarter contained 6.49 acres less than shown by the plat. The plat marked the south portion of the quarter as containing 80 acres, and the north as containing 72.49 acres, and the patents and subsequent conveyances so described the tracts. *Held*, that the deficiency should be deducted proportionally from the north and south half quarters on the basis of 80 and 72.49 acres, respectively, since the rule applied to original surveys, that the interior lots in fractional sections shall be made to contain the legal number of acres, and that any deficiency shall be charged against the outer lot, does not apply when the original surveys are found to be erroneous.—*Caylor v. Luzadder* (*Ind. Sup.*), *36 N. E., 909.*

13. Where the evidence shows it was the intention of the parties to a deed that only the land comprised within the description by courses and distances should be included, such description will control one by number of lot and block.—*Mullaly v. Noyes* (*Tex. Civ. App.*), *26 S. W., 145.*

14. The lines of a survey, in the absence of calls for artificial or natural objects, are controlled by courses and distances. —*Ratliff v. Burleson* (*Tex. Civ. App.*), *25 S. W., 983.*

15. The position of old fences may be considered in ascertaining disputed boundaries.—*Hoffman v. City of Port Huron* (*Mich.*), *60 N. W., 831.*

16. Where the boundaries of a tract are doubtful, the quantity of land becomes a material consideration in fixing the limits.—*Hoffman v. City of Port Huron* (*Mich.*), *60 N. W., 831.*

17. A boundary line supposed to be the true boundary, and long acquiesced in as such, affords better evidence of the location of the true line than a survey made after the original monuments have disappeared.—*Hoffman v. City of Port Huron* (*Mich.*), *60 N. W., 831.*

18. In ejectment where the title depends on the location of a certain highway along the shore of Lake Huron, as between a survey record of the highway made by the proper authorities and a use of the margin as a highway at times by means of a single road, and at other times by means of several parallel roads at varying distances from the shore line, the survey, being more certain, must control.—*Hoffman v. City of Port Huron* (*Mich.*), *60 N. W., 831.*

19. Where land was described in a deed with reference to a highway, and the only neighboring highway that had been cut out or definitely located was established by a survey, and located a short time before the deed was executed, the presumption is that the parties contracted with reference to such survey.—*Hoffman v. City of Port Huron* (*Mich.*), *60 N. W., 831.*

20. Written descriptions of property are to be interpreted in the light of the facts known to the parties at the time.—*Hoffman v. City of Port Huron* (*Mich.*), *60 N. W., 831.*

21. A plat of land owned by plaintiff's grantor represented the distance thereof, from north to south, to be 1,117 feet, and dedicated a street bisecting the land from east to west, and an alley bounding the land on the south. Thereafter he conveyed to plaintiffs lots bounded on the south by the alley and on the north by the street, having a depth of 506 feet, as represented by the plat. *Held*, that though the land owned by the grantor was 1,157, instead of 1,117 feet from north to south, as shown by the plat, plaintiffs, having the number of feet their deeds called for, were not entitled to half of the surplus 40 feet, and to move the south line of the street 20 feet north.—*Williams v. City of St. Louis* (*Mo. Sup.*), *25 S. W., 561.*

22. Where a navigable stream is declared by statute to be one of the boundaries of a municipality, the low-water line, and not the thread of the stream, is the boundary.—*State v. Eason* (*N. C.*), *19 S. E.*, *88.*

23. Where a stream is the boundary of a tract of land, and it suddenly abandons its channel, and makes for itself a new one, by cutting across a neck or bend, the middle of the old channel of the stream still constitutes the boundary of the tract, though there may be no water flowing therein. —*Bouvier v. Stricklett* (*Neb.*), *59 N. W.*, *550.*

24. Where the middle of a stream is the boundary line of land, and the water undermines the bank, and the soil caves in, and mixes with the water, and is washed away, the owner must stand the loss, and the middle of the new channel will be the boundary.—*Bouvier v. Stricklett* (*Neb.*), *59 N. W.*, *550.*

25. One purchasing land bordering on a meandered lake takes to the center thereof ratably with other riparian owners. —*Olson v. Huntamer* (*S. D.*), *61 N. W.*, *479.*

26. A timber culture entryman, obtaining a patent from the government to land bordering on a meandered lake, acquires reliction to the center of the lake occasioned by its drying up after the day of his entry.—*Olson v. Huntamer* (*S. D.*), *61 N. W.*, *479.*

27. The title of a riparian owner on a non-navigable lake or pond does not extend beyond the natural shore.—*Noyes v. Collins* (*Iowa*), *61 N. W.*, *250.*

28. Where a lake 5 miles long and 100 rods wide is drained in one year by an artificial ditch and by the cutting into it of a river, a riparian owner does not acquire title to the bed of the lake under the law of accretions.—*Noyes v. Collins* (*Iowa*), *61 N. W.*, *250.*

29. The patentee of a fractional subdivision bordering on a navigable lake, which has been meandered in the government surveys, takes title to all land beyond the meander line formed by the gradual subsidence of the lake, since the

boundary is not the meander line, but the water line.—*Knudsen v. Omanson* (*Utah*), *37 P., 250.*

30. An owner of lots on a meander line, which was supposed to separate such lots from a lake which in fact did not exist, does not own the land covered by the supposed lake, but it is a part of the unsurveyed domain of the United States.—*Grant v. Hemphill* (*Iowa*), *59 N. W., 263.*

31. Where a navigable lake is of such size that entire sectional subdivisions are included therein, the owner of a fractional subdivision of a section meandered by the United States survey along the margin of the lake does not own all of the lake lying within the extended lines of his subdivision. Jones v. Lee, 43 N. W., 855, 77 Mich., 35, followed.—*Grand Rapids Ice & Coal Co. v. South Grand Rapids Ice & Coal Co.* (*Mich.*), *60 N. W., 681.*

32. The United States have not repealed the common law as to the interpretation of their own grants nor explained what interpretation or limitation should be given or imposed upon the terms of the ordinary conveyances which they use, except in a few special instances, but these are left to the principles of law and rules adopted by each local government where the land may lie.—*Middleton v. Pritchard, 3 Scam. Ill., 510.*

33. The grants of the government for land bounded on streams and other waters without any reservation or restriction of terms are to be construed as to their effect according to the law of the state in which the lands lie.—*U. S. Sup. Ct., Hardin v. Jordan, 29 N. W. Rep., 813.*

34. The determination of the drain commissioner establishing a drain, within 10 days from which, under 3 How. St. § 1740*e*4, notice of certiorari to review the proceedings must be served on such commissioner, is his final order establishing the drain, required by section 1740*d*8, and an unsigned document is not such an order as is contemplated thereby.—*Loree v. Smith* (*Mich.*), *58 N. W., 1015.*

35. It is within the discretion of the drain commission to determine the outlet of a drain.—*Gillison v. Cressman* (*Mich.*), *59 N. W., 321.*

36. In suit to enjoin the further construction of a drain which was to have its outlet in another drain already constructed across land of complainant, who was a minor, and had had no notice of the proceedings, it appeared that she had not been assessed anything, and that no injury would be done to her land, and that the suit was not commenced until near the completion of the drain. *Held*, that an order remanding the drain proceedings to the commissioner, with instructions to take the necessary steps to obtain the right of way across complainant's land, and providing that the expenses already had were to become a part of the whole expense of the drain, and that, in case complainant filed a stipulation to discontinue the suit, her cost should be allowed her, gives her no cause for complaint.—*Gillison v. Cressman* (*Mich.*), *59 N. W., 321.*

MICHIGAN ENGINEERING SOCIETY.

BUSINESS TRANSACTIONS.

The annual convention of the society was held at Hotel Downey in Lansing, on January 15, 16 and 17, 1895. The business meeting of the society was held Wednesday afternoon. The report of the Secretary was made and approved. He reported that in addition to the matters reported in connection with the annual meeting of the board of directors he had done all in his power to secure a good number of papers on timely topics, and had carried out so far as he was able the wishes of the directors in preparing for the convention. The following is the report of the

ANNUAL MEETING OF BOARD OF DIRECTORS.

The annual meeting of the board was held at Hotel Downey, Saturday, October 10, 1892, at 9 a. m. There were present President Muenscher, Secretary Hodgman and Director Skeels. The Secretary's annual report was read and approved. Applications for withdrawal were received from L. P. Breckenridge, B. Kent, R. C. Carpenter, E. H. Mumford, P. O'Connell, I. G. Sowter, and W. H. Van Devoort. Prof. Breckenridge requested a remission of dues on the ground that he had but just joined the society and had no opportunity of attending any of its meetings. This request was granted. The other applications for withdrawal were also granted, Mr. Sowter's on condition that he comply

with the by-laws and pay up his dues, which he had promised to do.

The memberships of C. F. R. Bellows, E. H. Jones, J. M. Sanborn, E. F. Guild, Geo. L. Davis, Milo H. Davis, J. A. Thompson and H. O. Duerr were annulled for non-payment of dues. Mr. Beden's wife having written that he was sick and not able to pay at present, his case was deferred.

In the case of R. C. Pope, who refused to pay for advertising, the Secretary was directed to take measures to collect the same.

It was voted to submit to the next annual convention the question of changing the time of the annual meeting of the board of directors to the last Wednesday in September. It was also voted to submit the question of raising the annual dues to the next convention.

The Treasurer's report was read and approved.

The ballots for officers were canvassed and the following found and declared elected:

President—Geo. S. Pierson.
Vice President—John J. Granville.
Secretary-Treasurer—F. Hodgman.
Directors—J. B. Davis, Dorr Skeels and C. E. Greene.

The ballots for plans for designating corners of subdivisions of sections were canvassed and Mr. Hodgman's plan had 9 votes, Mr. Teed's 8, with 4 scattering on plans not all previously presented.

It was voted to hold the next convention at Lansing, beginning Tuesday, January 15, and that Wednesday evening be used for a social gathering, with music and supper by ourselves. The further arrangements for the convention were left in the hands of the President and Secretary and local members.

SECRETARY'S REPORT TO BOARD OF DIRECTORS.

In accordance with the requirements of our laws, I would respectfully submit the following report of business transacted by me since my last report was made and acted upon.

Immediately after the Jackson convention I went to work to secure advertising in order to be able to publish the Annual. For a time it seemed as though it would be impossible to raise the necessary means without resort to an assessment of the members, and I sent out with the annual ballot for members, on the first Monday in March, another ballot to learn the views of the members relative to an assessment. The responses were, with a single exception, unanimous in favor of an assessment if found necessary. As soon as that fact was learned, I let the job of printing the Annuals to Robert Smith & Co., of Lansing. In the meantime several of the members had assisted in procuring advertising, which was timely and of great service. For the purpose of keeping expenses down some matter was omitted from the Annual that would otherwise have appeared, especially a number of illustrations. The annual was out earlier than last year.

EXCHANGES.

The societies with whom we exchange reports have some of them apparently met with similar difficulties to our own as only a part of them have been received. Nothing has been heard from the Ohio, Indiana, or either of the Canada reports.

WITHDRAWALS.

A number of members have asked leave to withdraw from the society, most of them because of having removed from the State and joined other societies. With the exception of Wm. R. Coats, I. V. Sowter and L. P. Breckenridge, they have complied with the by-laws, and are entitled to withdrawal

from the society. Of these Mr. Sowter has written that he would send in his back dues, but doubtless has forgotten it. Prof. Breckenridge had but recently joined the society, and never had an opportunity of attending the meetings, and asks that his dues be remitted. The following are the applicants for withdrawal: L. P. Breckenridge, R. C. Carpenter, B. Kent, W. R. Coats, E. H. Mumford, P. O'Connell, W. H. Van Devoort and I. V. Sowter.

The following members are two years behind with their dues, and their membership should be annulled unless good reasons are given to the contrary. A copy of the notice required by by-law No. 6 was mailed to each one of them on the 1st of September, 1894. C. F. R. Bellows, S. N. Beden, J. M. Sanborn, E. F. Guild, E. H. Jones, C. G. Taylor, Geo. L. Davis, Milo H. Davis, Jas. R. Thompson and H. O. Duerr.

Owing to the desirability of having a member for the University on the board of directors and the difficulty of securing their attendance at the present time of meeting, I would suggest that the articles of association be amended so as to fix the meeting at an earlier date.

R. C. Pope of Chicago, advertised in the Annual for 1893, for which he gave a formal order. He has not paid for it. I sent him bills a number of different times and drew on him through the bank, to all of which he paid no attention. I drew on him the second time with orders to protest if not paid. He refused to pay and was protested. He is evidently a man for engineers to look out for, and not patronize in any way.

TREASURER'S ANNUAL REPORT.

During the past fiscal year I have received and disbursed for the society, the following sums:

RECEIPTS.

Cash on hand Oct. 11, 1893	$67 66
Received from fees and dues	269 44
From advertising	328 50
From sales of Annuals	17 25
	$682 85

EXPENDITURES.

Paid expenses of board of directors	$24 09
Paid freight and express	15 24
Paid stamps and envelopes	28 24
Paid printing circulars, ballots and committee report	32 90
Paid secretary's expenses getting out Annuals	13 16
Paid printing 1893 Annuals	81 79
Paid printing 1894 Annuals	215 01
Paid advertisement in Eng. News	8 00
Paid stenographer	49 70
Paid American Digest	5 00
Paid wrapping paper	1 46
Paid protesting Pope draft	2 29
Paid secretary's salary	100 00
Balance on hand Oct. 9, 1894	105 72
	$682 85

The society owes nothing. It has due it from members who are only one year behind in dues, $40.

There is also due from advertisers who may probably be considered good, $33. Notwithstanding hard times, both advertisers and members have been more prompt as a rule in paying up their accounts than in former years.

F. HODGMAN,
Treasurer.

Subscribed and sworn to before me a notary public in and for Kalamazoo county, Michigan, this 9th day of October, A. D. 1894.

[SEAL.]

WILBUR C. POND,
Notary Public.

After the reports were read and approved, on motion of Prof. Greene, it was voted that $100 be appropriated for salary of the Secretary and Treasurer.

The following candidates for officers for the next year were nominated:

For President—Geo. S Pierson of Kalamazoo.
Geo. L. Wells of St. Louis.
John J. Granville of Saginaw.
For Vice President—Frank F. Rogers of Port Huron.
John J. Granville of Saginaw.
For Secretary and Treasurer—F. Hodgman of Climax.
For Directors—Wm. Appleton of Lansing.
Wm. B. Sears of Saginaw.
C. E. Greene of Ann Arbor.
J. B. Davis of Ann Arbor.
H. K. Vedder of Agricultural College.
Dorr Skeels of Grand Rapids.
Edgar French of Battle Creek.

Attention was called to the desirability of having at least one member of the board a person who lives in or near Lansing, to make sure of a quorum at the annual board meeting. This meeting must be held in Lansing, and twice they have been obliged to adjourn for want of a quorum, making much additional expense.

It was voted to amend the third article of the articles of association of the society so that the portion relative to the time of the annual meeting shall read as follows: "The annual meeting of said corporation shall be held the third Wednesday of September, at Lansing. It was also voted to amend by-law 7. by changing $2.00 to $3.00, so as to read "There shall be an annual due of $3.00, payable on the first day of the annual convention," etc.

This closed the business transacted at the regular business meeting. During the convention other business was transacted as follows:

A committee consisting of E. W. Muenscher, Wm. B. Sears, M. C. Taft, John Randall and D. Skeels was appointed to investigate the action of frost upon cement mortar to report at next convention.

A committee consisting of E. O. Sellers and F. F. Rogers was appointed to investigate and report at next convention on the question of joining the Association of Engineering Societies.

A committee consisting of D. Skeels, E. W. Muenscher and F. F. Rogers was appointed to examine and report on exhibits made before the society.

The committee reported as follows:

Gentlemen of the Michigan Engineering Society:

Your committee on exhibits beg leave to make the following report:

Among the exhibits is a copy of the sixth edition of Hodgman's Manual of Land Surveying just issued. We notice as new features in this valuable work the following: In computing areas by latitudes and departures after resolving the figure into its component triangles and trapezoids he does away with the use of double meridian distances and computes these figures according to the ordinary rules of geometry, thus simplifying the computations using less figures and doing away with double areas. For examples under this head he uses actual cases taken from the field notes of the United States survey in this state.

He has introduced the methods of abbreviating field notes used in the United States land office, and a plan for abbreviating references to the corners of the subdivisions of a section.

He has substituted the latest United States surveying instructions, those of 1894, which are much modified from former instructions. In this is included the method of obtaining a true meridian from observations of Polaris at any time when visible.

J. G. Alexander exhibits a patent drafting table, manufactured at Grand Rapids, which in our opinion is the best and most practicable table on the market. The table exhibited is 37x48 inches in size. Three other sizes are manufactured. It is easily adjusted to any required elevation, either when used horizontally or any angle of inclination. As Prof. Davis says of Hodgman's Manual: "It is simply unique," and must be used to be appreciated.

Mr. Gurley exhibits a plain engineer's transit. The tripod is the best extension tripod we have seen. The change to radical clamp on lower plates we commend. The bearings are all good and perfect. Many engineers would prefer that the body of the leveling screws be made larger to avoid breaking, and that double abutting screws be used on the lower plate instead of a single screw and opposing spring. The transit has the graduations on rolled silver and we consider the transit a good instrument for the work it is intended to perform.

(Signed.) D. SKEELS,
E. W. MUENSCHER,
F. F. ROGERS,
Committee.

The report of the committee was approved.

The thanks of the society were voted to the secretary.

Invitations were received from members representing Port Huron, Saginaw, Grand Rapids and Kalamazoo, to hold next convention in their respective places.

The thanks of the society were unanimously voted to Messrs. Berger, Gurley and Beckmann for their papers on the magnetic needle.

The Wednesday evening session was devoted to social intercourse, music, stories and non-professional articles by the members.

F. HODGMAN,
Secretary.

A special meeting of the board of directors was held on Thursday, January 17, and the following applications for membership were approved:

FOR SENIOR MEMBERS.

Knud Sophus Riser, bridge engineer, Detroit, Mich.; W. H. Wallace, general manager of Bay Port Quarries, Bay Port, Mich.; M. Walker, contractor of water works, Fenton, Mich.; J. W. Harris, civil engineer and contractor, Charlevoix, Mich.; V. Sebring Hillyer, mechanical engineer, Grand Rapids, Mich.

The applicants were balloted for in March and all were elected to membership.

IN MEMORY OF THE DEPARTED.

JOHN H. FORSTER, OF WILLIAMSTON.

"In his ample library he can commune at will with the good and wise of all times, but his heart often yearns for his old comrades who have cast off the veil of the flesh, and are hidden from his mortal eyes.

The writer must fain confess, that the path set for him to travel through the wilderness of life, has not been free from danger and privations of an uncommon kind.

So it is with unfeigned gratitude, that he acknowledges the goodness of his Heavenly Father in rescuing him from so many perils, and he looks to a merciful Savior for ultimate pardon and peace.

"So long Thy power has blest me,
Sure it still will lead me on
O'er moor and fen, o'er crag and torrent,
Till the night is gone,
And with the morn those angel faces smile,
Which I have loved long since, and lost awhile."
—From Lead Kindly Light, No. 512, Church Hymnal.

Very sincerely your friend,

JOHN HARRIS FORSTER."

November, A. D. 1892.

GUY H. CARLETON, OF SAULT STE. MARIE.

"The entire life of Mr. Carleton was an active and useful one. He was probably more closely identified with the early development of the city and county than is any living man. He was a conscientious christian and a member of the Presbyterian church for years and one of its first supporters. Kindly in disposition and unostentatious in deportment every man with whom he came in contact called him friend. His life was punctuated by kindly acts to his fellow men."

—*Sault Ste. Marie News.*

FRED B. PELHAM, OF DETROIT.

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Among the officers and employés of the railroad company Mr. Pelham was a favorite for his quiet and gentlemanly demeanor and his thorough self-reliance upon his own mental equipment. Chief Engineer Torrey and Henry Russel, the attorney of the road, were among his sincerest friends."

—*Detroit Journal.*

CHARLES B. HYDE, OF JACKSON,

civil engineer, died at his home at Jackson, Mich., March 12, 1895. Mr. Hyde was born at Franklin, Conn., Oct. 2, 1816. In 1841 he was graduated from the Rensselaer Institute, following which he was an instructor in mathematics in the Academy at Mexico, N. Y. In 1851 he was appointed assistant engineer on the Oswego Canal where he remained until 1860, for the latter part of this time being first assistant engineer under resident engineer, M. S. Kimball, with headquarters at Syracuse. He removed to Michigan in 1866 and was engaged in the survey and construction of the Air Line R. R. between Niles and Ridgeway until 1872 when he entered the employ of the Michigan Central R. R. Co. In 1873, Mr. Hyde was appointed city engineer at Jackson, Mich., and served six years. He was engaged at various times as contractor for sewers and paving, and in 1883 was contractor for grading on the Mich. Air Line Division of G. T. R'y east of Jackson. Soon after the completion of this work he retired from active practice and lived quietly at his home.

WM. G. FARGO.

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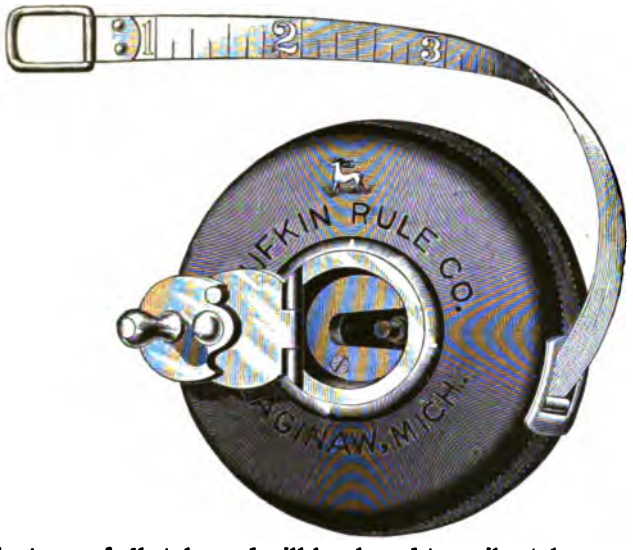

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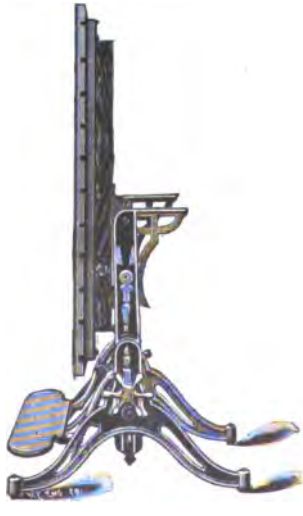

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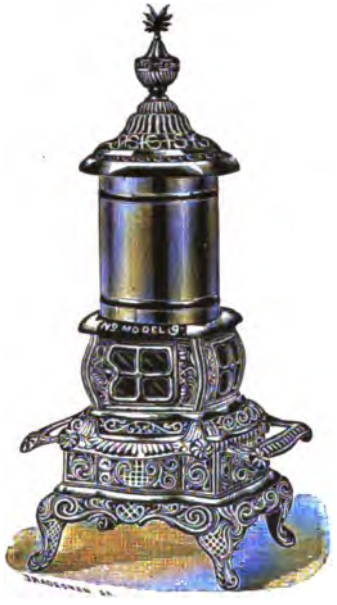

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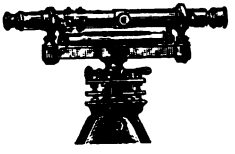

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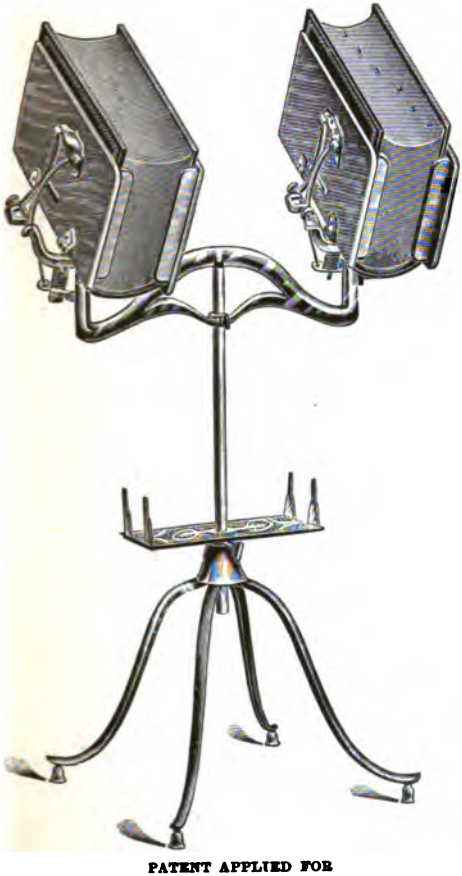

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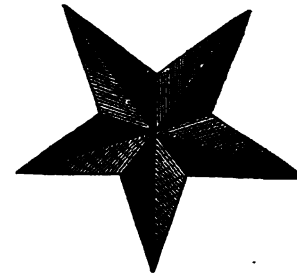

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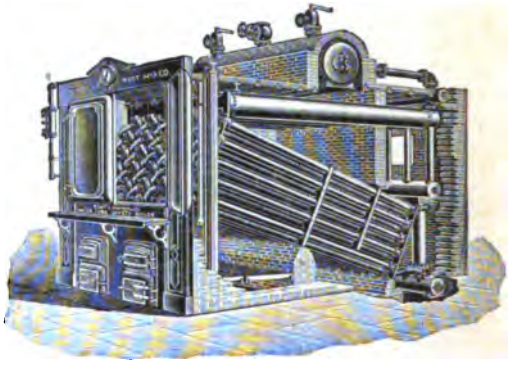

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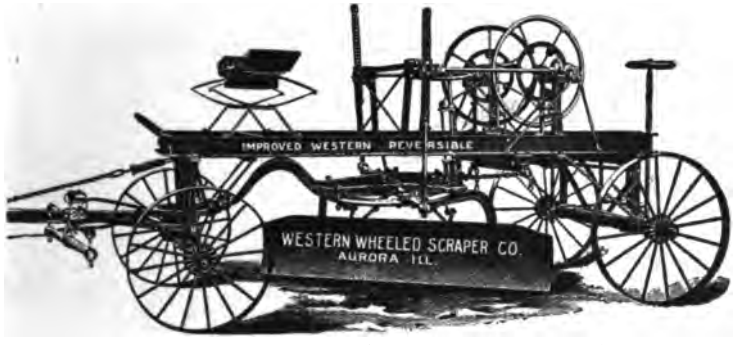

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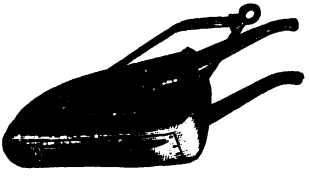

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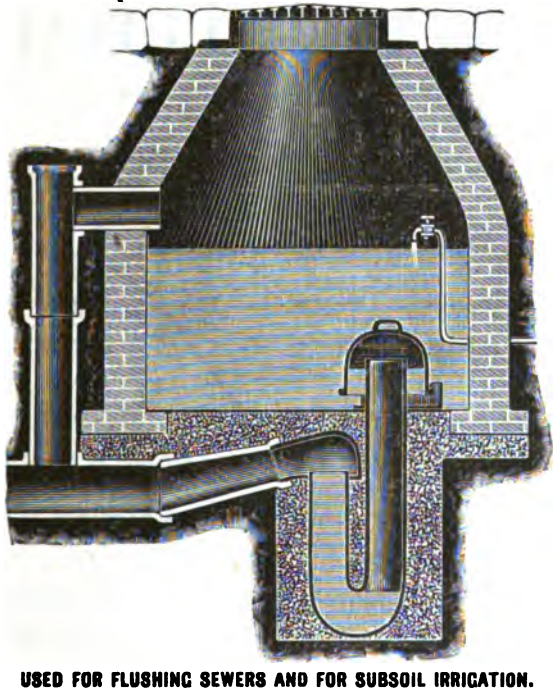

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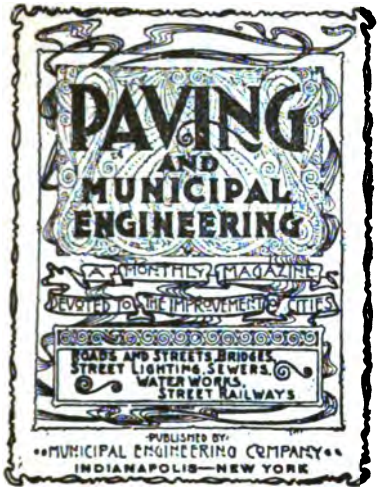

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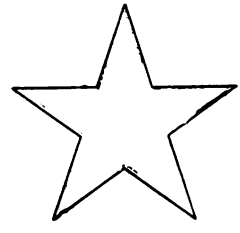

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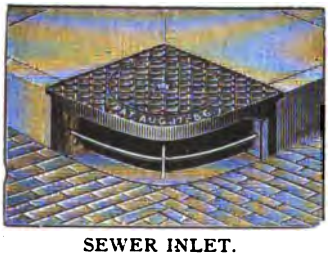

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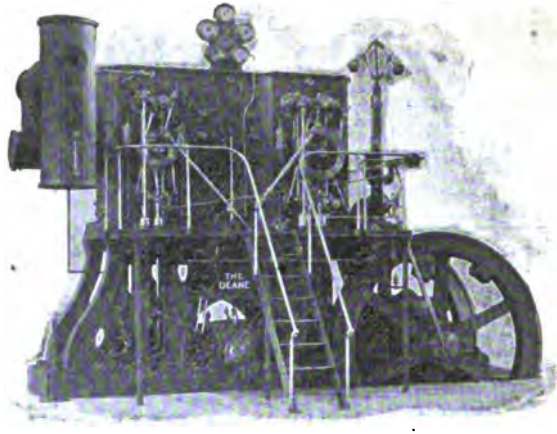

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MODERN METHODS OF SUPPLYING CITIES WITH PURE WATER.

BY ALLEN HAZEN,
MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

Mr. President and Gentlemen of the Society:

I was particularly glad to accept the invitation of your President to speak at this convention, for, although a native and resident of New England, I have had the pleasure of visiting frequently and of living for a limited period in the Middle and Western States, and I appreciate the fact that although your population has not yet become as dense as it is upon the Atlantic Coast, you still have many problems in water supply and sewage disposal of peculiar difficulty and interest; so that with the rapidly increasing populations of your cities, fields for professional investigation and work are opening up which are hardly equaled in the East.

It has been my good fortune during the past few years to have been able to visit an unusually large number of the water supplies of the great cities of Europe and America, and to become acquainted with many of the men most active in designing and executing the improvements and extensions of these supplies, and to become familiar with the methods which they use.

In visiting water works in different cities and in different countries, I have been continually impressed with the diversity in ideas in regard to water supply which are prevalent in different parts of the world, and it is often really marvelous, considering the international spirit of the last part of the nineteenth century, how many different local methods are used in a most satisfactory way, and which are yet hardly known, or at least are not properly understood, outside of the limited localities in which they are used. Thus the impounding reservoirs which

are so largely and successfully used in England and in portions of the United States, are hardly known upon the Continent of Europe; and the methods of securing ample and satisfactory ground water supplies, which have been brought to a high state of perfection in some of the countries in Continental Europe, have received but limited application elsewhere; and the processes of filtration of river and lake waters, which are used upon an almost gigantic scale in England, Holland and Germany, have received but little application in France and Austria, and are scarcely known as yet in the United States, least of all in the Middle and Western States, where from the geological and geographical conditions, filtration is most needed.

It is true that many methods of water supply have been developed to meet special conditions and are not applicable to other and different conditions, but at the same time, it must be admitted that a diffusion of information in regard to the various methods will often lead to the discovery that methods can be used with advantage in other localities than those to which they are now confined. This is particularly the case in the United States, where, with our enormous area, we have the widest range of conditions, and with them the opportunities to try the various methods of securing pure water.

The rapid growth of our cities and the limited capital at their command, have too often led our authorities to secure water from the nearest stream or lake without much regard to its quality, and although the methods which must be used in different parts of the country to secure pure water differ widely, no one will deny that in every state in the Union there is ample opportunity for the introduction of better methods in collecting the water so necessary to large parts of our population.

The rocky hills of New England have deep valleys between them which are often too steep and stony to be suitable for agricultural purposes, and are frequently located near manufacturing towns, where if they had been prepared expressly for that purpose, they could hardly have been better arranged as sites for impounding reservoirs. In the Middle States, with alluvial plains or slightly rolling country, impounding reservoirs

become difficult or impossible, but the large rivers of muddy water, which flow by nearly all of the great cities in that region, afford a splendid field for the adoption of the methods of filtration which have been so successfully used under corresponding conditions in Germany; and, in the far West, as well as in many localities scattered over the whole country, there are chances for developing ground water supplies similar to those which have been so successfully obtained on all sides of the Alps in Europe, in France, Germany and Austria, and like which we have nothing in the United States.

There are three principal methods of obtaining a good water supply for a city. The first, and in some respects the most satisfactory method, consists in drawing the water from the ground through which it has passed and in so doing has become thoroughly purified from the innumerable impurities which so often render surface water objectionable. In case the ground water discharges naturally over the surface it is called a spring water supply. In New England, even the largest springs yield only a quantity of water entirely inadequate for the supply of even small cities or towns, and our engineers hardly think of them in designing public water supplies; but in other parts of the world there are springs so large as to be adequate for the supply of even great cities. The largest city so supplied is Paris, with its population of two and one-half millions, which draws a minimum of fifty-three million gallons daily from springs located in three separate directions from the city at distances of from sixty to one hundred miles, while a new supply is contemplated from other and still larger springs twice as far to the east. Vienna also is supplied from springs having their origin in the snow-capped limestone mountains of the Semmering, sixty miles to the south of the city, and Munich has a magnificent supply from springs in the foot-hills of the Alps.

Many other cities are supplied with ground water taken from points where there is no natural overflow to the surface. In these cases the water was formerly collected by so-called filter galleries or collecting conduits often built near or parallel to rivers, but in the more recent works it has usually been

found better to substitute tubular wells for the filter galleries, for, as a rule, the water can be more cheaply collected in that way, and its flow can be more satisfactorily controlled.

Among the great cities supplied with ground water in this way are Budapest, which draws its water from wells along the Danube; Leipsic, which is supplied by an extremely interesting series of wells in an abandoned bed of the River Mulde; Dresden, with its filter gallery by the River Elbe, and Cologne supplied by wells near the River Rhine, and a considerable number of English cities supplied from wells sunk in the chalk, including a part of London where a population of nearly half a million is supplied in this way.

In the United States, ground water has been extensively used for supplying small cities and towns, and a few large cities have been wholly or partially supplied in this way. Brooklyn was originally supplied from wells and still derives considerable water from this source, although the water so obtained is mixed with pond and reservoir waters, so that the supply as a whole cannot fairly be called a ground water supply. Charleston, Memphis and Dayton are said to be supplied by artificial wells, and Los Angeles is supplied from galleries in the gravel near the Los Angeles River. Lowell has for years endeavored to secure a supply of ground water from wells near the Merrimac River and some of its tributaries, but owing to the limited quantities of water obtained, is still obliged to draw a considerable part of its water from the river. Among the smaller cities, Waltham, Newton and Brookline, in Massachusetts, are supplied from wells or galleries along the Charles River. and large numbers of the smaller cities are supplied in a similar way. But looking at the matter broadly, ground water supplies have not received anything like the attention which they deserve in the United States, and the supplies which we now have are not in any measure comparable to the magnificent European ground water supplies which I have mentioned.

The second method of obtaining a good water supply is from an impounding reservoir or natural lake upon an uninhabited or but sparsely populated water-shed. This is pre-emi-

nently the English method of water supply. Liverpool, Manchester, Bradford and Dublin have expended millons upon millions of pounds sterling in securing such water-sheds and in bringing the water so obtained through long lines of aqueducts to the respective cities. The supply for Liverpool, obtained from the magnificent dam upon the Vyrnwy River in Wales, seventy-seven miles from the city, is one of the best known of these supplies. Birmingham is commencing to develop a similar supply from a water-shed over eighty miles from the city, to furnish water for nearly a million people, and in London there are many persons desirous of going to Wales for a water supply, the estimated cost of which is one hundred and eighty-eight million dollars, although the persons desiring such a supply are undoubedly in the minority, and there is no immediate prospect that the present supplies from the Thames and the Lea will be abandoned.

New England, with conditions in many respects similar to those of old England, has largely followed English precedent, and the use of impounding reservoirs is the most common method of water supply in the New England States, and, in a measure also, along the entire Atlantic Coast. Boston, New York, Baltimore, and to a certain extent, Brooklyn, have long been supplied in this way, and the water supplies so obtained, from a sanitary standpoint, are the best of the great water supplies in the United States.

Among the most important works in the United States for developing supplies of this character should be mentioned the new Croton dam for New York, now in course of construction, and the Nashua River supply for Boston and its suburbs. Boston, as you know, has a population of about half a million and is surrounded by some twenty-seven suburbs within a distance of ten miles from the State House, having an aggregate population equal to the population of the city itself. Boston had nearly reached the limit of the capacity of its water supply and many of the suburbs were pressed for water to meet even their present needs, and the qualities of a number of the present supplies were not all that could be desired. The voluntary co-operation of so many separate municipalities in

securing a general water supply could hardly be expected, and to meet this peculiar condition of affairs, the State created a Metropolitan Water Board with full powers to borrow money to pay for the construction of a masonry dam upon the Nashua River, 150 high, which will flood an area 4,195 acres to an average depth of 46 feet, forming a reservoir with a capacity of 63 billion gallons. The Board is also authorized to construct the necessary aqueducts and pipe lines to convey the water to the various municipalities requiring it; and the expenses incurred, including interest on the debt and the payments to the sinking fund to retire the loan at maturity, are apportioned among the various municipalities taking the water in proportion to their respective wealths and populations.

The estimated first cost of this work is nineteen million dollars, in addition to which a part of the Boston Water Works will be taken and operated in conjunction with the new supply at an additional cost of one-third as much more. The appropriation of twenty-seven million dollars, made by the Legislature to carry out this work is, at first thought, somewhat imposing, but after a critical examination of the sums which in past years have been spent in extending the water works of the various municipalities, and the sums which it would be necessary to expend in any case in order to keep up the supplies, it is apparent that this cost is not excessive, and it is further found that the income from the sale of water in the district to be supplied is so great, that with the increase which can be reasonably expected, it will fully meet the interest on this cost, as well as the sinking fund necessary to retire the indebtedness at maturity, and the interest and sinking fund on the bonds now outstanding, without increasing the present water rates.

The method of securing good water supplies by impounding reservoirs is but rarely applicable in the Middle States, both because there are no corresponding areas of practically waste land free or nearly free from population, and because the country is so flat that impounding reservoirs of sufficient magnitude would involve so much shallow flowage that a good quality of water could not be expected from them.

For the cities in this region which are also from their position unable to secure an adequate supply of ground water, the third method of securing a pure water supply, namely, by means of filtration, is almost the only one which can be used.

The subject of filtration* has, within the last few years, commenced to attract a good deal of attention in America, and it is often supposed that it is a comparatively new and almost experimental method. It is new to the United States, but not to the world. As long ago as 1839, sand filters were built to filter a portion of the water supplied to London, and the process was so successful that its use rapidly extended until all the water for London and for numerous other English cities was filtered; and in the fifties, filter plants commenced to be constructed in Germany. In 1876 it was reported by a Commission investigating the subject, that there were over one hundred places in Great Britain that systematically employed sand filtration to purify their water supplies. Since that time the use of filtration has steadily and rapidly increased.

Sometime since, I prepared a list of certain European cities in which I knew that sand filtration was employed for purifying the public water supplies, and the aggregate population of these cities exceeded fifteen million people by the last census, although I did not include a large number of other cities in which filtration is undoubtedly used but in regard to which my information was not complete, nor the hundreds of smaller cities, the names of which it would often be impossible to obtain. Taking this into account, it is by no means an excessive estimate that over twenty millions of people in Europe are now regularly supplied with filtered water. It is difficult to properly appreciate the magnitude of this number, but some conception of it can be obtained by stating that it was nearly equal to the aggregate population of all cities and towns in the United States having public water supplies from all kinds of sources, in 1890.

A process which has been so widely used can hardly be called an experimental process, and you will not be surprised

* The construction of filters, their theory, operation and results, have been fully treated by the author in the "Filtration of Public Water Supplies," John Wiley & Sons, New York, 1895.

when I tell you that so much information has been obtained in regard to it that filters can be built with just as great confidence in the results to be obtained from them as would be felt in the success of a masonry dam to hold back the water of a brook.

Among the great cities supplied with filtered water may be mentioned London, where five million people are supplied with two hundred million gallons of water daily, filtered through one hundred and twenty acres of sand filters, not including the considerable population supplied from wells in the chalk; Berlin, where one million six hundred thousand people are supplied with filtered water drawn from the two rivers flowing through the city; Liverpool, where nearly a million people are supplied with filtered water, most of it drawn from the impounding reservoir mentioned above; Hamburg, with a population of six hundred thousand, supplied with filtered water drawn from the much polluted River Elbe, as well as the great cities of Amsterdam, Rotterdam, Birmingham, Leeds, Bradford, Breslau, Madgeburg, Warsaw, St. Petersburg, Copenhagen and Antwerp.

In England, Holland and Germany, a majority of the inhabitants of all great cities are supplied with filtered water, and those not so supplied are, with few exceptions, supplied with ground water, which is also filtered water, although filtered by natural instead of artificial processes.

The objects of filtration are two-fold; it removes from turbid waters the mud and disagreeable tastes and odors which they so often contain, and renders them attractive and palatable, and for this reason, even if there were no other advantages to be obtained, filtration would be desirable and often worth more to a city than its cost. But there is a second reason for filtration which affects even more directly the welfare of our cities, and that is, the great improvement in their health which may be anticipated, and in fact, which has actually resulted from the introduction of filtration. The cases in which this improvement has been noticed are so numerous that I should tire you if I attempted to give you an account of even the most important of them, but you will permit me to mention a few of the most important cases.

London draws its water supply from two small and much polluted rivers, the Thames and the Lea. The populations per square mile upon the water sheds of these rivers are much greater than upon those of the Merrimac, or the Hudson, or the Allegheny, or the Ohio, or in fact, than upon almost any American stream used for water supply. Many years ago, water was used from these streams without filtration, and London suffered as severely from typhoid fever, cholera, plague and other diseases which may, and probably did, have their origin in the water, as any other city; but since the introduction of filtration, there has been so great an improvement in the health of the city that the death rate from typhoid fever is lower than in almost any American city, and cholera has only made its appearance to any considerable extent since the use of filters, on one occasion, that being in the early sixties, when it was found by investigation that the outbreak followed the temporary failure to supply filtered water by one of the water companies, and the outbreak was nearly confined to the area which received water from that source.

Hamburg, in 1892, was the only city in Germany, and in fact, almost the only great city in Western Europe, that used unfiltered river water for its public supply, and it was no accident that it was Hamburg, and Hamburg alone, that suffered severely from cholera in that year. This outbreak resulted in one month in over twenty thousand cases of cholera and eight thousand deaths, and was directly attributed to the use of unfiltered water from the polluted river Elbe. At the same time, Altona, a city immediately below Hamburg upon the river, and so near as to be connected with it by several lines of street cars, on which the fare from one city to the other is only two and one-half cents, drew its water supply from the Elbe, but at a point lower down where it was subject not only to the pollutions that affected Hamburg's water supply, but where it had also received the entire sewage of both Hamburg and Altona, and notwithstanding this most unusual amount of pollution, the water was so thoroughly purified by filtration before being supplied to Altona, that the inhabitants of the city remained substantially free from cholera.

excepting the few cases directly imported from Hamburg. This case is particularly instructive, for the river Elbe, at Altona, had received the sewage from at least six million people living in large cities, and not including the populations of the smaller towns and country districts which are not sewered; and at this time, owing to the twenty thousand cases of cholera in Hamburg, it must have contained an extraordinary number of the bacteria which cause cholera, and the fact that cholera gained no foothold in Altona, beyond a limited number of cases, most of which were directly imported from Hamburg, is conclusive proof of the value of filtration in protecting the health of a city.

Breslau, Berlin, Schiedam, Antwerp and a hundred other cities draw their water supplies from sources polluted even more seriously than those which are properly regarded as so objectionable in the United States, but filter them, and afterwards supply them to populations having uniformly such low death rates from those diseases which are ordinarily conveyed by drinking water that they are hardly equaled in this respect by even the most healthy cities of the United States.

But it is not necessary to go outside of our own country for illustrations in this line. The cities of Hudson and Poughkeepsie, in New York, take their water supplies from the Hudson River, upon which they are located, and notwithstanding the pollution of that river, which has caused repeated epidemics of typhoid fever in Albany, where the water is used in its raw state; these cities taking their water from the same source and filtering it, have been constantly protected from water-carried diseases. A yet more striking case is furnished by the City of Lawrence, in Massachusetts, which three years ago constructed a filter for the purification of its public water supply. This filter, although following in its general lines the forms used in European filters, was the direct result of the investigations of the Massachusetts State Board of Health at its experiment station in Lawrence, of which I had the privilege of being in direct charge for nearly five years, under the direction of Mr. Hiram F. Mills, to whose devoted energy and foresight are due both the experiment station and the filter for the public water supply of the City of Lawrence.

Prior to the construction of the filter, the city had had a death rate from typhoid fever which was exceeded by only a few of the larger cities in the United States, and this death rate was directly attributed to the use of the river water polluted by the sewage from the numerous cities upon its banks. Cases of typhoid fever in Lawrence were continually present for many years, and continued up to the time that the filter was put in operation. For six years before this time there were, on an average, over fifty deaths annually from this cause, and the numbers were very constant, ranging only from forty-seven to sixty for the various years. After the filter was put in operation there was a prompt and decisive drop in the death rate, which has ever since been but a mere fraction of that which had formerly existed, and of the deaths that still occur in Lawrence from this cause, a large proportion are among operatives in some of the mills where unfiltered river water is used for washing purposes, and in spite of the rules to the contrary, conspicuously posted in every mill, some of the opratives continue to use the water for drinking.

Dr. Copeland, Biologist at the Lawrence Experiment Station, has kindly secured for me a statement of the deaths from typhoid fever during the time since the filter was put in operation. For the year 1894, there were twenty-four deaths, of which twelve were among people who were known to have drunk the unfiltered river water, and four others were supposed to have contracted the disease out of town, and in 1895 there were sixteen deaths, nine of which were of people who were known to have drunk the unfiltered river water. Even with these cases included, the number of deaths for the past year is thus less than a third of what it was before the commencement of filtration, notwithstanding the increased population.

It may be taken as a conclusion from European experience, as well as from the results at Lawrence, that properly constructed filters, operated in a suitable manner, will remove nearly all of the disease producing qualities in the raw waters now in use by so many of our cities, and will affect very great reductions in the death rates from diseases capable of being carried by water.

A question which you will ask is what such filtration costs and whether it is worth the price. I have recently been engaged in making plans and estimates for a very large system of filtration, which was proposed as an alternative to the impounding reservoir project which has been adopted for the supply of the city of Boston and its suburbs. It was proposed to take the water from the Merrimac River above the city of Lowell, where it is less polluted than it is at the point where it is taken for the supply at Lawrence, and to purify it by filtration and to deliver it to the city by pumping. This project involved the construction of thirty-two filter beds having effective areas of one acre each, and covered by vaulting as a protection against frost, the total estimated cost of these beds, with the necessary appurtenances, being $2,180,000. It was proposed to increase the filtering area from time to time as required by the growth of the city, and plans were made for the ultimate construction of eighty acres of filter beds.

The total cost of the acqueducts, reservoirs, pumping machinery and land damages required for this project, together with the capitalized cost of pumping and operating the filters, amounted to $17,463,000, or about 92 per cent. of the cost of providing a corresponding supply of unpolluted water from the Nashua River, and it was thought that the natural purity of the latter supply, and the greater security in operating the system, more than offset the difference between the costs of the two projects, and the gravity supply was therefore adopted.

Although this work will never be executed, the estimates which were prepared with great care, have allowed me to accumulate considerable information with regard to the cost of filtration on a large scale at current American prices. This cost of filtration will differ widely with local conditions, and it is impossible for me to give you an estimate which will be correct under particular conditions, but for moderate sized cities, it seems probable that the cost of filters will rarely exceed $3.50 per inhabitant, and the running expenses, including the interest on the cost of construction and the payments for sinking funds upon the same basis, will not exceed 35 cents per inhabitant annually, and where the local conditions are quite favorable,

figures materially lower than this estimate may be anticipated. Putting the same thing in another way, it may be said in a general way, that the cost of filtration will add about ten per cent. to the cost of water as now supplied, although the percentage increase would be greater than this where water has been pumped at a minimum of expense from an improper source in the immediate neighborhood of a city.

We must now consider the question as to whether or not the advantages to be secured are equal to this cost. Great engineering works like the construction of filters will not be undertaken to save a single life nor to prevent a dozen cases of fever. It must be shown that the advantages to be obtained are comparable with the expenditures involved, upon something the same basis that would be used in discussing the merits of other life saving devices, or of the abolition of grade crossings.

The injuries resulting from the use of impure water are many. To call your attention to only a few of them, I might mention the objectionable appearance, taste and odor of such water; the causation of diarrhœa and other minor diseases, which are hardly noticed upon the mortality reports, but which are none the less uncomfortable for the people suffering from them; the losses, direct and indirect, resulting from typhoid fever in a city, loss of time for those suffering from it, doctors, nurses and hospital bills and the loss of the lives of those dying. Then there is the danger from cholera, and while we hope that this dread disease will not again gain a foothold on our shores, we know from all past experiences that should it do so, it would attack the cities with polluted water supplies, and we should gladly pay for purifying such supplies for much the same reason that we pay insurance rates to protect ourselves from a great and terrible, although remote danger. To consider all of these causes of loss resulting from bad water would require too much time, and I shall for the present throw out all but one of them, namely, the loss from deaths by typhoid fever.

Typhoid fever is essentially a disease of youth and early middle age, a very large majority of the cases being of people between fifteen and fifty years of age. It is also a disease of

all classes, affecting the rich as much as the poor; in fact, it sometime seems as if it had less foothold in the slums than elsewhere, where some of our recently arrived brothers from foreign shores are so accustomed to filth in every form, that they are apparently impregnable to the typhoid germs.

Taking these facts into consideration, we shall not be inclined to estimate the value of the lives lost from this cause at less than $5,000 each, and if we take this estimate, and the cost of filtration as given above, we shall find that from a purely financial standpoint, filtration will pay in a city where it effects the reduction of seven deaths annually per 100,000 of population, and in a case where the reduction amounts to seventy cases, the saving will pay for the cost of the filters in a single year. Upon this basis, according to the census of 1890 there were five cities in the United States with populations of over 50,000 each, and with an aggregate population of 690,760, which used unfiltered surface waters and had so many unnecessary deaths from typhoid fever, that at $5,000 each, the saving due to filtration would have paid for the entire cost of filtration in the first year that the filters were in use. In addition, there were sixteen other cities with an aggregate population of 3,717,560,where filtration would have paid for itself in two years or less, and still eighteen others with an aggregate population of 3,238,617, where filtration would have saved seven or more lives annually per 100,000, and would have more than paid for the interest and cost of operation of filters upon the basis given above. These estimates are upon the very liberal assumption that twenty-five deaths from this cause are inevitable, or rather that this number would result from importations from less healthy neighbors, and would occur with ever so good a water supply under present general American conditions.

Some of these cities may have been influenced by unusual local conditions in 1890. Others have in one way or another improved their water supplies since that date, and there are several cities in which the present death rates are materially lower than those given in the census. On the other hand, it is equally true that a number of cities, including some of the larger ones, have since that year had severe epidemics of

typhoid fever, which have given very much higher rates than those of 1890. These fluctuations change the order of the cities in the list from year to year, but they do not change the general facts, which are as true to-day as they were in 1890.

Nearly all of the great cities of the United States are supplied with unfiltered surface waters, and a great majority of the waters are taken from rivers and lakes at points where they are polluted by sewage. The death rates from typhoid fever in these cities, whether they are compared with better supplied cities in this country or with European cities, are enormously high. Such rates were formerly common in European cities, but they have disappeared with better sanitary conditions. The introduction of filters has often worked marvelous changes in Europe, and in Lawrence the improvement in the city's health was prompt and unquestionable, and there is every reason to believe that the general introduction of better water in American cities will work corresponding revolutions.

The conditions in the United States have been somewhat exceptional. The growth of our cities, particularly in the west, has been phenomenal, and in the urgent necessity of providing a water supply ample in quantity, the equally important question of quality has been all too often overlooked. But this condition of affairs cannot last. Many of our cities are beginning to realize the need of better water, and the comparatively small opposition to a twenty-seven million dollar project for supplying Boston with water, several million dollars of which are directed towards securing a high quality of water as distinct from quantity, is evidence that we are moving in the right direction, and we may confidently expect that when the need of pure water is more generally known and felt by the American people, and when it is realized that the methods of securing good water supplies are comparatively well known and are quite beyond the experimental stage, we may confidently expect that our cities will abandon the filthy and unhealthy practice of using unfiltered river and polluted lake waters, and will put the quality as well as the quantity of their supplies up to standards not exceeded by those of any country.

The President.—Gentlemen, the paper is before you for discussion. Inasmuch as there has been a great deal of interest manifested by the citizens of Saginaw in this paper, and as they are here in considerable numbers to-night, the discussion will not be limited to the members of the society, and any gentleman who feels himself at all interested in this subject, is at liberty to discuss it or to ask questions to draw out the fullest possible discussion of the paper.

Mr. Williams.—The gentlemen seem to be waiting for some one to break the ice. Perhaps I have as good a right to do it as anyone. As far back as I can remember, almost ever since the introduction of the water-works systems in these two cities, there has been occasionally, periodically, we might say, some expression of desire for a better supply of water. The people of the East Side did much better than their neighbors on the West Side in locating their intake, but I do not think there are many citizens of Saginaw who care to drink even the water here. The chief end and aim of these water supplies seem to be to get water to sprinkle lawns and put out fires. I think I am safe in saying that the majority of the people of this city are supplied with wells of one form or another, and I think I am also safe in saying that there have been many dry wells this summer, and if you go to your physician, I am satisfied he will tell you that there has been more typhoid fever this season than is usual. If you look in various treatises on typhoid, you will find it maintained that whenever there is an extreme drouth there is a high death rate from typhoid fever, and it has become a proverb that low ground water is synonymous almost with a typhoid fever epidemic. Typhoid has raged extensively in all parts of the State this year. In the state of Massachusetts where most careful investigations have been carried on, and where the great majority of people obtain water from public supplies, the statement is made, after a careful review of the statistics, that they found no great difference between those years in which there was extreme drouth, and those years when there was an excessive rainfall, which goes to show that the matter of drouth affecting the development of typhoid fever, is largely due to the use of surface wells.

There are many citizens of Saginaw who believe that an abundant water supply could be obtained by the sinking of deep wells in this city. There are many wells about town which have been sunk from 90 to 125 feet and have obtained quite an abundant supply of good water. There is, I believe, on record, an account of one or two wells, struck accidentally, in which this stream flowed at the surface, but as the parties who were drilling for these wells were drilling for something beside fresh water, it was not investigated, and would probably be difficult to find again. On the other hand, many of these wells have not found this vein of water which is supposed to underlie the city, and it becomes a grave question to know whether there is a sufficient quantity of water in the strata underlying Saginaw, to supply it with the amount of water necessary for the uses of such a city. Of course there are plenty of places in the world where larger cities than Saginaw are supplied with ground water, but very few correspond in topographical and geological conditions with Saginaw. But we have the three rivers, uniting above the city, with a drainage area of 3,600 square miles. While you have had low water here, I think there is no one who dares to say that it was impossible to take from the Saginaw River all the water that these cities could legitimately use. Mr. Hazen has indicated the methods that should be applied to this water to render it as good as from deep wells. I have taken occasion to look into the matter a little, in order to estimate what it might cost your city to provide itself with water taken from the Saginaw River, at any point which might be convenient. I have been perhaps, somewhat sanguine as to the growth of Saginaw, and thought possibly you might want to provide for 100,000 people; but when we look back at the growth of some other cities, (Detroit for instance that in 1886 had but 100,000 and now has nearly 300,000), I see no reason why you might not anticipate that at some time in the future you might be called upon to supply 100,000 people.

In determining upon a water supply for the city, the first thing to decide is, how much water are you likely to want. Careful experiments have been carried on in the East and the

consensus of opinion is that 100 gallons per capita per day is sufficient; Detroit uses about 150 gallons, but from some investigations which I have made, I am well satisfied that 75 gallons per capita covers every drop of water employed for useful purposes there. To be on the safe side, we will take 100 gallons per capita per day, and we will assume 100,000 population, and that will call for 10,000,000 gallons per day. Now it is found that in hot days in summer, the consumption may exceed by 50 per cent the average, so that it will be necessary for you to provide for an additional 5,000,000 gallons in times of emergency, either by storage or filtration, I assume that you will provide a filtration area sufficient to filter this amount per day, which at most approved rates will require about seven acres. In addition to seven acres of land for filtration, you will need three acres for storage; I assume that land suitable can be purchased in the neighborhood of your East Side works at about $1,000 per acre; it may be I am too low—

(A voice, interrupting, "Take off nine hundred dollars,") (continuing)—Perhaps if the city wanted it, the price might go up.

Now Mr. Hazen, in his work on the Filtration of Water Supplies, published by John Wiley & Sons, New York, has furnished some statistics as to the cost of water filters, and I have taken from it an average price of $30,000 per acre, and I have allowed $20,000 per acre for your reservoir, and an additional $20,000 to take care of such additional pumps as might be necessary, and it gives a total of $300,000 investment to provide a filter plant. The interest on this, provided your bonds are floated at 5 per cent, would be $15,000. The operation of your filter, taking the average of 10,000,000 gallons per day, would cost $15,000 a year more. Your pumping during the past year, has cost you $12.00 per million gallons. At this rate, to pump the supply estimated would cost $56,000. The interest on the present indebtedness of your works, as I obtained it from the report for 1893, is about $26,000. I add an allowance of $20,000 per year for extensions and $28,000 for the sinking fund, to take care of the bonds which are now falling due, and those that would have to be issued in

the event of your introducing such a supply, and we have a total annual expense of $160,000. Now 100,000 population represents 20,000 families, and on this basis, the average per family assessment, to raise this revenue, would be $8.00. In the city of Detroit last year, it was $8.34. In 1886, when Detroit had 100,000, the average assessment was $10.23.

Now for the benefit of those who will say that I have assumed entirely too high figures for your population, I will drop it to a figure perhaps more nearly in consonance with what you will admit as probable, and take 60,000. The average family assessment for providing a supply for this number of people would be less than $10.00 per annum. In view of these facts, it seems to me that there is no reason why Saginaw should not have as good a supply of water as any city in the world, and why that department, which is now a continual drag upon your tax payers, taking out about $30,000 a year from the general tax levy, should not be made a self supporting institution. In Detroit we are continually having a surplus, which is only avoided by reducing our rates. There is no reason why Saginaw should not have a thoroughly self supporting system; if you give the people here water that they can use in their houses without fear th re is no question but that in a short time it will be in universal use.

(Applause).

The President.—I believe that Prof. Greene has interested himself in this subject to some extent.

Prof. Greene.—(No response, being interrupted by the—

Question.—I would like to ask Mr. Hazen if this filtration must take place solely through sand?

Mr. Hazen.—Other substances have been suggested, but I do not know that they have been successfully used on a large scale. In Europe all of the public filtration plants use sand for the filtering material. The objection is sometimes raised that sand of suitable quality cannot be easily secured, but as a matter of fact, I do not think any alarm need be felt on that ground, because there are methods of preparing the sand from mixed materials at reasonable expense; and along the great lakes and greater rivers of the country there are sand beds that

are in every way suitable, and if sand cannot be found in one locality, low freight rates can be secured which will allow the sand to be brought from the points where it is available.

Filtration is undoubtedly somewhat expensive, but some of us who have been studying the problem have come to the conclusion that the benefits obtained from it are very great, and that the American people are wealthy enough to be able to afford it, and to secure pure water in that or some other way which yields an equally healthy supply.

The President.—Are there any other questions? During the last few years I have been forced into the study of water supply to some extent and in looking over the subject of filtration, it has occurred to me as being simply a matter of straining, which involves to a large extent the size of the vegetable matter in the water to be taken out, and the size of the particles in the sand filter. As Mr. Hazen has had a great deal to do with these filters, I would like to have him develop that point somewhat.

Mr. Hazen.—The effect of the process of filtration is a dual one. It is in part a straining process, and in part a biological action.

The properties of the water which cause disease are, for the most part, I might say almost exclusively, the bacteria in it. The bacteria which are objectionable are roughly about one ten-thousandth of an inch long. The solution of the problem of straining them out by passing the water through a material composed of particles so small that the bacteria would be unable to pass through its pores is almost impossible, but it is a property of sand that when water is passed through it, it accumulates upon itself masses of bacteria, not necessarily injurious bacteria, for there are many kinds, and these accumulations form on the sand grains a sort of jelly in which the bacteria in passing become entangled and held until they are destroyed and oxydized. There is always air in solution in the water and the organic matters always present are attacked by the organisms upon the sand grains, which live on such organic matter in the water and destroy it, so that the process

of filtration consists in a large measure of the destruction, or as we may call it, a sort of burning up of these matters.

The process of filtration, however, is something more than straining; it accomplishes results that could not be accomplished by straining, and in the filters at Hamburg and Berlin, it is found by actual tests that the bacteria are often eliminated to the extent of more than 99.9 per cent, and considering the minuteness of the organisms in comparison with the sizes of the passages between the sand grains we can see that there is something besides simple straining going on.

Mr. June.—I would like the gentleman to go a step further and state whether ultimately this process of consumption of which he speaks will be continuous, or whether in the course of time these filters will become so clogged that they will need to be removed?

Mr. Hazen.—A large part of the organic matter is absolutely destroyed, but of the more stable matters retained in the sand the great bulk are retained in the upper layer, and at intervals this upper layer is removed. At Lawrence half an inch is taken off six times a year. The sand can be washed and used again if desired. The body of the sand remains pretty nearly in its original condition. It is even more efficient as a filter after it has been in use for a time, than at first. So after a filter has been in use for a year or so, it ordinarily gives a slightly better result than it did in the beginning. Whether the sand would last forever or whether it would be necessary to replace it after ten or twenty years, depends largely upon the treatment it receives and is really a matter of minor importance, because the more expensive parts of the filter, that is the walls, bottom, regulators, conduits, etc., remain in any case. As a matter of fact, filters have been in use in London since 1839, nearly 60 years, and when the sand has been replaced, it has been at long intervals, and the expense is not serious.

The President.—I would like to ask if it has not been found in the tests that have been made, or are now being made at Lawrence, that the bacteria found in the water

are less at the extreme end of the system than right near the works where the freshly filtered water is pumped.

Mr. Hazen.—That is true. Before the water was filtered ninety per cent of the bacteria were removed by sedimentation or died natural deaths in the reservoir and in the mains; but notwithstanding that reduction, the ten per cent that remained were enough to give the city a death rate from typhoid fever not to be envied. Since the filter was put in operation, it has removed perhaps ninety-nine per cent. of the bacteria, and while the numbers cannot be computed accurately because they are so small, yet probably nine-tenths of the remaining ten per cent are removed as before, in the reservoir and mains, so that the water now used contains only one-tenth of one per cent., where formerly it contained ten per cent. These reductions in the numbers of objectionable bacteria are somewhat obscured by the growth in moderate numbers of certain harmless forms of bacteria, which while not injurious in any way, mask the actual removal of the objectionable forms.

The President.—Has a limit been put upon the number of typhoid or other germs allowable in a given quantity of water?

Mr. Hazen.—There are no set rules in regard to that. In Germany there has been an arbitrary rule that the number of bacteria per cubic centimeter should not exceed 100, corresponding to about one hundred thousand in a quart, but the bacteria in water are by no means all injurious; if they were it would be dreadful to think of what might happen. As a matter of fact, it is an extremely small proportion of them that are injurious. The injurious ones are generally from sewage. The other bacteria which are present in vast numbers are not injurious, and the life and growth and numbers of these harmless forms depend upon a whole chain of circumstances. In the United States, with our higher summer temperatures, these harmless forms often multiply rapidly, and a good many more than 100 per cubic centimeter will often occur without giving cause for alarm. This is a question which must be approached with great care.

Mr. Rogers.—As we have been highly instructed and entertained by this paper of Mr. Hazen's, I move that we extend to

him the heartfelt thanks of the society. Motion receiving support was unanimously carried.

The President.—Mr. G. S. Williams of the Detroit Water Works, whom we have heard to-night on the discussion of this paper, has announced that his paper, which is on the program for to-morrow morning, will be "The Purification of Water," which seems to be a continuation of the subject before us to night, and we invite the citizens of Saginaw to come in and hear this paper also.

Mr. June.—I would like to ask Mr. Hazen in connection with this matter, what kind of water this is, which they filter, is it spring water?

Mr. Hazen—It is hardly necessary to filter spring water. That and other ground water supplies are almost invariably of such excellent quality that any expenditure to filter them would be money thrown away. The waters purified in Europe are river or lake waters. The waters of a number of lakes, not very different in quality from the waters of the great lakes, are filtered, and the water of rivers is almost invariably filtered before being used.

There are two classes of river water; one of them from rivers like the Merrimac in Massachusetts, the Thames in England, and the Hudson in New York, where the water has but a comparatively sluggish flow and carries but little sediment; but in the waters of the rivers mentioned there is a good deal of sewage and the water is injurious to health; and the other class of water from rivers, where there is a rapid current, and the water carries large quantities of sediment. The German rivers are almost all of this latter class. The waters from Hamburg, Bremen, Breslau, Stettin, Magdeburg and other cities are all drawn from rivers of this character which are not only muddy but polluted. In these instances it is found necessary to remove part of the mud by sedimentation, allowing the heaviest matters to settle before filtration, in order to reduce the cost of filtration, as otherwise the particles of mud would clog up the filters too rapidly, making a more frequent change of sand necessary.

The President.—If there is nothing further to be brought before the society this evening, a motion to adjourn will be in order.

Mr. Roberts.—I believe it would be quite proper for the citizens of Saginaw also to extend a vote of thanks to Mr. Hazen for this very able paper, and I desire to make a motion that the citizens extend a vote of thanks to Mr. Hazen as well as to the Michigan Engineering Society. Motion supported.

Mr. Blank.—In addition to that I would like to state that there have been a number of analyses made of the Saginaw water, and it has been condemned, and I am heartily glad that this article has been presented, to help educate the people in a knowledge of the danger in which we are. I heartily endorse the motion.

Carried unanimously by vote of the citizens of Saginaw who were present.

THE PURIFICATION OF WATER.

BY G. S. WILLIAMS,
CIVIL ENGINEER OF DETROIT WATER WORKS.

This paper also read before the Detroit Association of Graduate Engineers of the University of Michigan.

I have been led to the selection of this subject by the many erroneous ideas prevalent regarding both the methods of purification and the necessities for its application, and also by the very frequent indifference to the conditions which prevail in connection with public water supplies in general. In this paper no claim is made to originality—even in the method of presentation—and the bulk of the matter herein contained may be found in much more extended form in the excellent reports of the Massachusetts State Board of Health from 1887 to the present time.

It may be of interest to note that in Massachusetts above all other states, is the engineer accorded that consideration which the profession receives abroad and so truly merits here. In that state no commission having to deal with engineering subjects is considered complete without its engineer member. The feeling on this point was amply demonstrated in the selection of the Metropolitan Water Supply Commission last spring. Governor Greenhalge nominated on this commission three gentlemen whose qualifications as citizens could not be questioned, but the Legislature, after confirming the first two nominees, declined to confirm the third because none of the three were engineers. As a result the commission comprises among its members Mr. John R. Freeman, one of the best known hydraulic engineers in New England. Engineers are also to be found on the Railway Commission, the Highway Commission, the Metropolitan Sewerage Commission, and last but not least, the Board of Health. On the last named board, Mr. Hiram F. Mills, C. E., for years engineer of the Essex Milling Co. of Lawrence, and more recently the successor of

the late renowned James B. Francis, in charge of canals and locks at Lowell, has done probably more than any other member in the carrying out of those special lines of investigation which have made this board an authority, not only in America, but the world over. By his influence the Hydraulic Laboratory of the Essex Milling Co. was obtained for the use of the Board as an experimental station; and without compensation, at the sacrifice of a lucrative private practice, he has devoted much of his time to the work of experiment and has brought to it the keen insight and technical knowledge developed by a lifetime of hydraulic work, which has contributed most abundantly to its success.

This board called to its assistance among others, Dr. Thomas M. Drown, then Professor of Chemistry in the Massachusetts Institute of Technology and now President of Lehigh University; William T. Sedgwick, Professor of Biology in the Massachusetts Institute of Technology; Frederick P. Steers, now Chief Engineer of the Metropolitan Water Board; Albert F. Noyes, now a member of the Metropolitan Sewerage Commission, and Wm. M. Brown, now the Chief Engineer of the last named commission, Mr. Allen Hazen, Mr. Geo. L. Fuller, now in charge of the Louisville filtration experiments, as well as many other specialists of note.

I am further indebted in the preparation of this paper to the excellent treatise on "The Filtration of Public Water Supplies," by Mr. Allen Hazen, and to a paper read before the Engineer's Club of St. Louis, by Mr. Robert Moore, and published in the "Journal of the Association of Engineering Societies" for January, 1895, and also to the recent work of Professor and Mrs. Frankland, "Micro-organisms in Water."

It is an old dictum that running water purifies itself, and some have so far developed this theory as to state that the water of a flowing stream is completely purified in twenty miles. In spite of the revelations of the observations and experiments of the past ten years there are many today—waterworks men among others—that will stoutly maintain the theory, and I have known of one case where the representative of a water company contended that six miles flow was suffi-

cient for purification when the decaying remains of a diseased cow were found in the water about seven miles above the intake of his works. In the light of recent investigations no more misleading doctrine in connection with water supply was ever foisted upon an innocent and unsuspecting public, unless it be that chemical analysis alone is sufficient to determine the wholesomeness of a water to be used for domestic purposes. These twin heresies, bred of the same original error, are so intimately connected that their discussion will be undertaken together. The impurities found in flowing water comprise certain inorganic or mineral substances in suspension, usually harmless, and more or less decayed organic matter of both animal and vegetable origin, partly in suspension and partly in solution, in itself not dangerous, together with microscopic living organisms both animal and vegetable, and lastly bacteria, organisms so small that with the most powerful microscopes we can barely distinguish them. As an example, the typhoid bacillus magnified 1100 times is not so large in body as our common house fly. The inorganic matter is made up of potash, soda, lime, magnesia, iron and alumina in combination with chlorine and carbonic, sulphuric and silicic acids. The organic matters are composed of carbon, nitrogen, oxygen and hydrogen, animal matters containing more nitrogen and less carbon than vegetable matters.

The process of decomposition in the organic matter takes place as follows: The carbon is first oxydized by the oxygen from the air mingled with the water, the resulting compounds being ammonia and carbon dioxide, next the ammonia is oxidized to nitrous acid and this is again oxidized to nitric acid, which, combining with the mineral constituents, forms a nitrate and ends the process. So far as the conditions of this process are concerned the chemical analysis tells us with fair accuracy in what stage the matter in the water may be, but it fails entirely to indicate the presence of those minute living organisms which constitute the real source of danger in drinking waters.

The results of a chemical analysis as usually given show: 1, the quantity of chlorine; 2, the amount of so called free

ammonia; 3, the amount of albuminoid ammonia; 4, the amount of nitrites; 5, the amount of nitrates; 6, the amount of fixed residue remaining after heating to a dull red with sodium carbonate; 7, the loss by so heating, and 8, the amount of oxygen consumed when the sample is boiled for a fixed length of time with permanganate of potash.

The chlorine, in itself harmless, if in excess of the normal quantity in waters of the particular locality, indicates previous sewage pollution.

The *free ammonia* which, however, is almost never *free* as the hydrate but is ordinarily the chloride or carbonate, and the nitrites, harmless in themselves, indicate organic matter in a state of partial decomposition. As *free ammonia* is a prominent constituent of sewage, it has been claimed that this is an evidence of sewage pollution, but high *free ammonia* is often found in waters in which there is no possibility of sewage pollution, so we must only say that it indicates partially decomposed organic matter.

Rep. Mass. S. B. H. Water Supplies 1887-1890 p. 550.
" " " 1892 p. 319 et seq.

The albuminoid ammonia measures the amount of undecomposed organic matter, or more exactly the amount of nitrogen in it.

The nitrates indicate completed decomposition, and are harmless in the quantities usually occurring.

The fixed residue measures the mineral constituents and the loss on ignition is an indication of the volatile constituents.

The quantity of oxygen consumed bears some relation to the amount of carbon present, but different substances behave very differently with the permanganate of potash, and hence this factor is only useful in comparing similar waters and has no significance with waters of dissimilar origin and nature.

Rep Mass. S. B. H. 1892 p. 328.

So far as micro-organisms are concerned they are only indicated in the chemical analysis by a slight increase in the albuminoid ammonia which can in no way be separated from that due to partially decayed or dead matter. One of the best evidences of this is given by Prof. Frankland (Micro-organisms

in Water p. 101-102), in an account of an examination of the River Dee in Scotland, which supplies Aberdeen with its water. The examination covered forty miles of river and beginning at the source the number of bacteria per cubic centimeter was first only 88, at the next point of observation they had increased to 2,829, at the next they had decreased to 1,139, then they increased again to 3,780, decreased to 938, increased to 1,860 and finally decreased to 950, and yet through all these changes in which the increases were uniformly caused by added sewage, Frankland says, "It was found impossible by means of chemical analysis to detect any material alteration in the composition of the river, even immediately below each of the above sources of contamination."

The fact that chemical analysis does not indicate changes in the bacterial compositions of either sewage or water is shown by the following examples of analyses, taken at random from the Report of the Massachusetts State Board of Health for 1891, and covering a wide range of conditions.

PARTS PER 100,000.

	Free Ammonia.	Albuminoid Ammonia.			Chl'rine	Nitrogen as		Oxygen Consumed.	Bacteria Per C.C.
		Total.	Soluble	Insoluble.		Nitrates	Nitrites		
Lawrence Sewage.									
Average of daily Analyses for									
1888	1.5528	.6878	.1161	.5267	5.19	0	0	--------	1,000,000
1889	1.8439	.5540	.2909	.2631	4.92	0	0	--------	708,000
1890	1.8200	.6862	.3805	.3057	5.45	0	0	3.25	1,085,000
1891	2.2196	.7295	.3446	.3849	7.37	0	0	3.64	693,000
Analysis of									
July 3, 1890	2.50	.65	.51	.14	4.87	—	—	2.90	7,560,000
" 7, "	2.10	.81	.57	.24	7.07	—	—	3.30	807,000
" 14, "	2.75	.88	.88	.00	5.97	—	—	3.00	159,060
" 17, "	2.75	1.05	.55	.50	6.10	—	—	2.80	1,401,000
Effluents of Sewage Filters.									
Analysis of									
Oct. 2, 1891	.0242	.0144	—	—	10.46	3.06	.0018	.15	3,600
" 9, "	.0132	.0128	—	—	8.16	3.20	.0014	.14	50
" 16, "	.0012	.0144	—	—	8.02	1.67	.0080	.16	19,440
" 23, "	.0070	.0104	—	—	6.86	1.85	.0004	.18	138
" 30, "	.0102	.0096	—	—	7.10	1.66	.0012	.10	280
May 8, 1890 9:15 a.m.	.8000	.0500	—	—	4.39	2.75	.0200	.12	1,836
" " " 11:06 "	.8200	.0800	—	—	4.39	3.00	.0140	.13	1,404
" " " 2:42 p.m.	.8000	.0800	—	—	4.34	2.75	.0120	.14	6,318
" " " 5:24 "	.8500	.0500	—	—	4.36	3.00	.0180	.11	12,204
" " " 8:45 "	.8500	.0500	—	—	4.39	2.75	.0220	.12	1,026
Lawrence City Water.									
Analysis of									
Dec. 9, 1891	.0028	.0138	—	—	.25	.0280	.0002	.40	88
" 16, "	.0034	.0148	—	—	.21	.0330	.0002	.41	330
" 23, "	.0030	.0136	—	—	.24	.0320	.0002	.39	1,320
" 30, "	.0030	.0120	—	—	.22	.0200	.0001	.37	156

Prof. Drown discussing this subject, says: (Rep. Mass. S. B. H. Water Supply, etc., 1887-1890, p. 536). "Students of sanitary science have attempted to establish certain standards of purity of water based on the determination of nitrogen. These standards express limits for organic nitrogen, or albuminoid ammonia, free ammonia, nitrites and nitrates, beyond which the water containing them should not be used for drinking. Some of them have the sanction of sanitary congresses, and some are merely the expression of individual opinion. The application of these standards of purity has condemned many waters which were certainly unfit to drink, but it is equally certain that many wholesome waters have been thereby rejected. The following table from another part of the same report (p. 541) brings out this point:

PARTS PER 100,000.		Color.	Residue on Evap.			Ammonia.		Chlorine.	Nitrogen as	
			Total.	Loss Ig.	Fixed.	Free.	Alb'm'd.		Nitrates	Nitrites
Unpolluted Waters.	No. 1	0.00	5.00	0.70	4.30	.0000	.0022	0.08	.0060	.0000
	2	0.10	2.50	0.95	1.55	.0000	.0702	0.10	.0020	.0008
	3	0.60	5.15	3.25	1.90	.0000	.1252	0.11	.0000	.0000
	4	0.40	3.65	1.65	2.00	.0130	.0333	0.16	.0250	.0001
	5	0.30	3.25	0.95	2.30	.0000	.0136	0.63	.0050	.0000
	6	0.00	5.95	0.80	5.15	.0000	.0152	2.10	.0080	.0001
Polluted Waters.	7	0.10	10.75	2.05	8.70	.0124	.0284	0 19	.0150	.0009
	8	0.55	5.15	1.95	3.20	.0000	.0196	0.54	.0550	.0004
	9	0.10	5.00	0.85	4.15	.0016	.0198	0.58	.0200	.0004
	10	0.15	10.25	1.20	9.05	.0000	.0262	2.09	.0170	.0010
	11	0.15	12.70	2.10	10.60	.0664	.0263	2.41	.0800	.0025

"The fallacy of making 'standards of purity,'" continues Prof. Drown, "based upon the organic nitrogen, ammonia, nitrites and nitrates, is apparent when we consider that these substances are not injurious in themselves, at least to the extent which they are found in natural waters, and that the presence of any one of these substances in water does not in itself necessarily carry with it any indication of its origin. These standards are relics of the days in which the harmfulness of a water was supposed to be the direct result of the injurious action of specific substances found in it. The theory of today is that it is (in the large majority of cases) to the presence of micro-organisms in water that its harmful influence is due."

Thus the chemical analysis is seen to be often insufficient to determine previous sewage pollution in water, and in the

case of surface water it is often superfluous. As has been very pertinently remarked, "It does not need a chemical examination to decide whether a stream is polluted or not when one can see the sewage flowing into it."

If chemical analysis is not a reliable guide as to the quality of a water supply, it may very properly be inquired, "What is?" To this I would reply that every source of information bearing upon the waters should be investigated. The engineer should be called upon to ascertain all possible or probable sources of pollution, and the source of the water itself. This information should be given to the chemist who should then make his examination. The idea often prevalent in some communities that the way to get a fair result from an analysis is to keep the chemist in entire ignorance of the source of the water and everything about it, is most erroneous. While chemistry is an exact science and there is not likely to be much doubt as to the constituents found, the interpretation of results depends for its correctness on all the facts concerning the water being properly considered. Next the microscopist should be called upon to determine the organisms, vegetable and animal, that are recognizable with his instruments. These organisms may not be positively harmful but frequently give to the water disagreeable tastes and odors, so that their presence is not to be desired. Finally the services of the biologist should be invoked to determine the number and kind of bacteria present. It is only since 1882 that a method of accurate determination of bacteria has been known. This method consists in the forming of a so-called "culture" upon gelatine enriched with peptone or other substance in which the bacteria thrive by inoculating with a portion of the water to be examined, when each bacillus becomes a colony of hundreds or thousands, which clinging together can be readily counted by the aid of the microscope, and their peculiarities determined. The ordinary unit selected for microscopic and bacterial determinations is the cubic centimeter which is about the size of the ordinary player's die, the old nickle five cent piece being very nearly two centimeters in diameter. As an example of the number of bacteria present oftentimes, Lawrence sewage dur-

ing October, 1893, averaged 1,125,000 per cubic centimeter, and the lowest monthly average was that of September, which was 626,000.

The number per gram (about one-thirtieth of an ounce, Troy) in the faeces of a healthy man ranges from as low as 10,000,000 to 200 000,000, while those of typhoid fever patients contain as high as 1,000,000,000. "If we assume that a man discharges about seven ounces of faeces daily, this would give for typhoid patients 200,000,000,000 bacteria discharged daily per person" (Filtration of Public Water Supplies, p. 133). The number of bacteria found in sewage is usually higher, often double this number per person. Not all, fortunately, of these bacteria are dangerous, perhaps ordinarily not more than one in two or three thousand, but the faeces of typhoid patients contain the germs of that disease, and although in water there is no evidence that they, or any other disease germs increase, they retain their vitality for varying periods, and if granted favorable conditions will at once develop colonies of fellows. It is the possible presence of these latter organisms that renders chemical analysis fruitless for the purpose it has been so long considered final.

Now as to the self-purification of rivers, it takes place to varying extents in three ways. By dilution, by sedimentation, and by oxidation and light.

The first means is by far the most important. The inflow of pure or unpolluted water below the point of contamination reduces the percentage of dangerous organisms in the stream. This inflow of purer water comes not only from visible tributaries, but from subterranean streams flowing into the river at all points, so that while there may be no visible tributaries an immense increase may take place in the flow of the stream.

The second means of purification, subsidence, is due to the fact that the mineral matters and about half of the organic matter are merely in suspension and if the current be not too swift, these will settle by gravity to the bottom and may carry with them a considerable number of bacteria. On this account partially more bacteria are found in the lower than in the upper layers of a body of water. So a stream that has flowed

through a lake or pond or reservoir, may be expected to contain a smaller number of bacteria than it did before entering the same.

The effect of oxidation, supposedly promoted by aeration in the passage over falls and through rapids, is greatly overestimated. Examinations of Niagara River water above and below the falls showed practically the same bacterial composition. The experiments of the Massachusetts Board of Health (Report for 1892, p. 320), prove that oxidation of the organic matter from ammonia to nitrates only occurs in the presence and by the aid of certain bacteria, but the completion of the process is no evidence of the termination of life of any of these or other organisms. Moreover, the time required for oxidation of these organic matters in solution differs widely under different circumstances and the vegetable growths in the channel frequently mask the action of the process by appropriating its products at various stages (Mass. S. B. H. Rep. 1890–Pt. I, p. 575). Besides all this, the period of life of some bacteria has been studied, and among them, that of the typhoid bacillus has been found to be from fifteen to thirty days in Merrimac River water, and somewhat longer in the purer effluents of some of the filters, and these bacteria do not appear to be affected by oxidation, and some European experiments show that they are not affected by sunlight at a depth of nine feet in water. (Mass. S. B. H. Rep. 1892 p. 528). (Micro-organisms in Water, p. 372). How far would these bacilli travel in an ordinary river during a life time of fifteen days? I venture to say considerably more than twenty miles. Indeed we have the best of evidence that after traveling thirty-nine miles from Lowell down the Merrimac River through almost stagnant mill ponds and over dams and through rapids, the last fourteen miles of the journey being affected by tide water, they still had sufficient vitality to pass through pumps and water pipes and produce an epidemic of typhoid at Newburyport, in January, 1893 (Mass. S. B. H. Rep. 1892, p. 701), and the repeated epidemics of typhoid at Lawrence following those at Lowell nine miles up the river, give conclusive evidence of their vitality through similar vicis-

situdes for the shorter distance, although the water was stored for more than a week in the Lawrence reservoir, while some of the epidemics at Lowell appear to have been caused by the disease as far away as Concord, N. H., forty-eight miles up the river. Nor is an epidemic necessary to produce these results. Four cases of typhoid three miles above the intake of the Lowell water works in 1890 caused an epidemic in that city involving 550 cases and resulting in 92 deaths, which was immediately followed by one almost as severe in Lawrence (Rep. Mass. S. B. H. 1892, p. 668 et seq.). But it is not necessary to go to Massachusetts for evidences of the vitality of pathogenic bacteria. In the report of the Michigan State Board of Health for 1891 (p. 217) Prof. Vaughan gives analyses and experiments with samples of water from the Detroit River taken at Wyandotte, proving the water there to be contaminated by Detroit sewage and containing germs that were deadly to the lower animals and probably disease breeding in men.

The principal methods in use for the purification of water are sedimentation, bleaching, chemical precipitation, and filtration. The first is accomplished by bringing the water to rest for a comparatively limited time in shallow basins when the suspended matters fall to the bottom and the clarified liquid is drawn off from above. Bleaching is accomplished by storing the water for long periods in deep reservoirs by which means the color and many other disagreeable properties are removed and any dangerous bacteria are left to die a natural death. Chemical precipitation is accomplished by treating the water in tanks with chemicals which cause a deposit of both suspended and dissolved matters. But by far the most important method of purification is filtration.

The necessities of filtration are not nearly so well appreciated in America as in Europe. In Germany the law requires that every surface water used for a public supply shall be filtered, and minute regulations are enforced regarding the operation of each filter, including among other requirements a daily biological analysis of the effluents by a person of assured capability to conduct the investigations. In England, filtration of surface waters, though not universal, is extensive, and is almost

universal in Belgium and Holland and quite common in France. It is the opinion of some that filtration is only a straining process and hence removes only the substances in suspension. The error of this view will appear as we proceed with the consideration of our subject, but we will first glance briefly at the history of filtration, for which I am chiefly indebted to the paper by Mr. Moore.

The first sand filter was constructed at London in 1839 by Mr. James Simpson, engineer for the Chelsea Water Co. "This consisted essentially of a shallow reservoir with a collecting drain through the center and with lateral drains of porous tiles or bricks without mortar leading into the central drain. On top of this system of drains were laid from three to four feet of gravel and sand decreasing in fineness to the top. Through this sand bed water was allowed to percolate slowly into the collecting drains, whence it was led off to the wells for distribution." So successful was this device in removing sediment and improving the appearance of the water that in 1852 its use was made compulsory with all companies supplying London with surface water, and the filter was rapidly adopted elsewhere, both in England and on the continent. The earliest attention given to the subject in America appears to have been in 1866, when the St. Louis Water Board, then having under consideration the construction of new works, sent their engineer, Mr. James P. Kirkwood, to Europe to investigate and report on the subject of filtration. Though his recommendations regarding the St. Louis works, after being endorsed by the Water Board were rejected by the City Council, the report was published in 1869 and is even today considered almost a classic on the subject. So complete was it in description and so clear and ample in its suggestions and deductions that notwithstanding the improvements and developments of the process, it has remained until within a year the only treatise on filtration in the English language. At the time of his visit he found filtration plants in operation in Berlin, Altona, Nantes and Marseilles on the continent, and in Leicester, York, Liverpool, Edinburgh and Dublin as well as in London.

While the theory lasted that the harm in polluted waters lay in dead matters in suspension, this method of purification left nothing to be desired as by it turbid waters were rendered clear and as far as the eye could judge pure. But when in the course of time scientific investigation developed that the danger did not lie in the dead matter at all, but in minute living organisms, engineers, sanitarians and medical men alike stood aghast. The cost of obtaining natural water from unpolluted sources put it beyond the reach of many towns, and the preservation of streams unpolluted flowing through a densely populated territory was seen to be alike impossible. When it was discovered that the clearest and most sparkling of waters might be the most deadly, the benefits of filtration were regarded as chimerical. The sentiment at this time is well voiced in a paper by Mr. Charles Watson Folkard, associate of the Royal School of Mines of England, read before the Institution of Civil Engineers in January, 1882, which is quoted by Mr. Moore. After he had discussed the various methods of water analysis, he said: (Proc. Inst. Civil Engineers, Vol. 68, p.68) The conclusion that once contaminated, water never purifies itself sufficiently for dietetic purposes becomes inevitable; and as chemical analysis fails to give reliable evidence as to its fitness or the reverse, the author believes that the only safe test of the wholesomeness of a given water is by tracing it to its source and ascertaining that no objectionable impurities gain access to it. This will at once condemn all rivers flowing through a populous country; and when it is considered that a river is a natural drain of a district, into which everything soluble or suspensible finds its way, it will not be a matter of wonder that this is the case. No Conservancy Board can keep pollution out of a river; it must receive all the rain falling within its water shed (excepting of course that which is evaporated) together with the overflowings of cess-pools and the sewage of towns within the same area. It is part of the great circulatory system of the earth, which it is vain for man to attempt to control. This being so, it is evident that rivers, excepting near their source can only afford polluted water, and a problem utterly insoluble by man, is presented, viz., the purification of

foul water on a large scale." Continuing with regard to filtration, "This," he says, "is another remedy put forward as infallible by those who have not grasped the subject. How can filtration affect substances dissolved in water? And as far as the minute organisms found in putrescent bodies are concerned, they could pass a hundred or a thousand abreast through the interstitial spaces of ordinary sand as used for this purpose."

This paper was discussed by a number of very able men, among them the late Professor Tyndall and the preponderance of opinion was with the author. Mr. Homersham declared that in some respects and at some seasons filtration really injured the water by the collection of a layer of organic matter on top of the sand which furnished pabulum for the insects as he termed them, and Dr. Tidy said "One could no more analyze a water for a germ of typhoid than one could analyze a brain for an idea."

But right on top of these declarations, the very same year 1882, Dr. Robert Koch of Berlin, gave to the public the gelatine plate process of determining micro-organisms already described, which at once advanced bacteriology to the degree of an exact science. Among the many students who immediately seized upon this newly discovered agent of investigation, was Percy Farraday Frankland, Professor of Chemistry in University College, Dundee. He at once began an investigation of the work of the London filters, which has continued to the present time. His conclusions were first set forth in a paper before the Institution of Civil Engineers, in April, 1886, and later in reports to the Royal Commission on Metropolitan Water supply, then considering the supply of London, which were published by the Commission in 1893. In brief, Professor Frankland's conclusions were: That the London filters had practically no effect on the chemical composition of the water. That they had a most remarkable efficiency in removing bacteria, about 99½ per cent. of those in the raw water being removed; and finally, that this extraordinary biological efficiency depends upon the formation of a superficial gelatinous deposit or membrane on the top of the sand which acts as an almost impervious obstacle to the passage of micro-organisms.

Here was a revolution. As Mr. Moore very aptly says: "Mr. Folkard's army of microbes marching 'a hundred or a thousand abreast through the interstitial spaces' has somehow been put to rout and the cause of their discomfiture is found in the superficial layer of organic matter which according to Mr. Homersham should furnish the "insects" with "pabulum," all of which illustrates anew the extreme danger of '*a priori*' reasoning in matters of physical science."

The third conclusion of Professor Frankland, though supported by most European authorities, is not borne out by the experiments of the Massachusetts Board of Health. This subject is discussed by Mr. Hazen in "Filtration of Public Water Supplies" (p. 80 et seq.) as follows: "It was observed in Berlin and Zurich that the bacteria in the effluents were quite independent of those in the raw water and the conclusion followed that the filter stopped all of the latter and that the former were bred in the underdrains. It was, however, noticed that immediately after scraping (i. e. removing the sediment layer) for two or three days the bacteria in the effluents increased and it was concluded that before the formation of the sediment layer some bacteria were able to pass through the sand, and it was recommended that the first water filtered after scraping be rejected. Piefke at Berlin gave the subject careful study, and came to the conclusion that it was almost entirely the sediment layer which stopped the bacteria, and that the bacteria themselves in the sediment layer formed a slimy mass which completely intercepted those of the passing water. When the layer was removed by scraping, the action was stopped until a new crop had accumulated. In support of this idea he stated that he had taken ordinary good filter sand and killed the bacteria in it by heating it, and that on passing water through, no purification was effected—in fact, the effluent contained more bacteria than the raw water. After a little, bacteria established themselves in the sand and then the usual purification was obtained. Piefke concluded that the action of the filter was a biological one; that simple straining was quite inadequate to produce the results obtained; that the action of the filter was mainly confined to the sediment layer, and that the depth of

sand beyond the slight depth necessary to support this layer had no appreciable influence on the results.

The effect of this theory is to be still seen in the shallow sand layers used at Berlin and some other German works, although at London the tendency is to thicker layers. Piefke's deductions, however, are not entirely supported by his data as we understand them in the light of more recent investigation. The experiment with sterilized sand has been repeatedly tried at the Lawrence Experiment Station with results which quite agree with Piefke's, but it has also been found that the high numbers, often many times as high as in the raw water, do not represent bacteria which pass in the ordinary course of filtration, but instead enormous growths of bacteria within the sand supported by the cooked organic matter in it. It has been repeatedly found that ordinary sand quite incapable of supporting bacterial growths, being heated to a temperature sufficient to kill the bacteria in it, will afterwards furnish food for extraordinary numbers. A filter of such sand may stop the bacteria of the passing water quite as effectually as any other filter, but if so, the fact cannot be determined without recourse to special methods, on account of the enormous numbers of bacteria in the sand, a small part of which are carried forward by the passing water and completely mask the normal action of the filter. The theory that all or practically all of the bacteria are intercepted by the sediment layer, and that those in the effluent are the result of growths in the sand or underdrains, received two hard blows in 1889 and 1891, when mild epidemics of typhoid fever followed unusually high numbers of bacteria in the effluents at Altona and at Stralau in Berlin, with good evidence in each case that the fever was directly due to the water, Both of these cases came during extremely cold weather with open filters and under conditions which are now recognized as extremely unfavorable for good filtration. As a result of the first of these epidemics a series of experiments were made at Stralau by Frankel and Piefke in 1890. Small filters were constructed and water passed exactly as in the ordinary filters. Bacteria of special kinds not existing in the raw water or effluents were then applied, and the presence

of a very small fraction of them in the effluents demonstrated beyond a doubt that they had passed through the filters under the ordinary conditions of filtration. These experiments were afterward repeated by Piefke alone under somewhat different conditions with similar results. The numbers of bacteria passing although large enough to establish the point that some do pass, were nevertheless in general but a small fraction of one per cent. of the many thousands applied. The subject has more recently been studied in much detail at the Lawrence Experimental Station, and it now appears that the bacteria in the effluent of a filter are from two sources, directly from the filtered water and from the lower layers of the filter and underdrains. In general the bacteria from the latter source are low in cold weather, often almost *nil* while at Lawrence with water at temperatures varying from 70 to 75 degrees, in July and August, the numbers from this source may reach 200 or 300, but for the other ten months of the year rarely exceed 50 per cubic centimeter under normal conditions. In summer especially the latter seem to be greater in number at a low than at at high rate of filtration while the number of those passing through the filter increases with the rate of filtration. Therefore the increase of one may in part balance the decrease in the other and so keep the total at very nearly a constant figure for quite varying rates of filtration. The bacteria of the underdrains are harmless and are of no interest to us except as they mask the true action of the filter, but those coming through the filter are likely to be dangerous and increase rapidly with the increasing rate of filtration and slowly with decreasing thickness and increasing size of sand grain."

In connection with the investigations regarding water purification carried on by the Massachusetts Board of Health, experiments were also made on the purification of sewage. Two systems of filtration were tried, the continuous and the intermittent. In the former, as the name implies, the liquid to be filtered is fed continuously to the filter until its clogging requires that it be cleansed, while in the latter the inflow is stopped and turned on again periodically. For the purification of sewage owing to the large amount of matter to be disposed

of, it was soon discovered that continuous filtration was unsatisfactory, but intermittent filtration gave very good results. Strange as it may seem, it was further discovered that intermittent filtration through a bed of gravel the size of peas, gave nearly as good effluents as those obtained by passage through an equal depth of fine sands, and contrary to Frankland's determinations in the case of the London filters, it was found that marked chemical changes took place during the flow of the liquid through the filter, ammonia and nitrites being oxidized to nitrates by the aid of the bacteria which lodged in the filter, forming films over its grains while at each emptying and filling the interstitial spaces were filled with air which furnished the oxygen for the process. The results of filtration of sewage through a filter of gravel stones that would not pass a sieve of ⅛ inch mesh but would pass one of ⅜ inch mesh, where working at a rate of 80,000 gallons per acre per day for six days in the week, the sewage being applied intermittently during nine hours of the day, show that 98 per cent. of the organic matter was removed at this rate and an effluent afforded that was "colorless, generally clear with slight turbidity, and with slight odor." As to the bacterial efficiency under these conditions, 99 per cent. of those in the applied sewage were removed. The gravel was 5′ 5″ deep. At slower rates 40,000 gallons per acre per day, 97 per cent. of the organic matter was removed and about the same percentage of bacteria as in the former case (Rep. Mass. S. B. H. 1890, Pt. II, p. 565). These observations and those on a filter of stones from ¾ inch to 1¼ inch diameter giving similar results prove that the action of the filter is to no essential degree mechanical. That it is not a straining through fine pores. "In fact, the passing of sewage through filter paper in the laboratory, which has pores so fine that the process has been regarded as removing from a liquid all matter not in solution, removes from our sewage but 11 per cent. of the sum of the ammonias and about 80 per cent. of the bacteria, while the slow moving of the sewage in thin films over and between stones as large as one's thumb causes the removal for months at a time of 97 per cent. of the sum of the ammonias and 99 per cent. of the bacteria. The removal

is not a mechanical one of holding back these substances, but a chemical change, in which these organic substances are burned, forming products of mineral matter which pass off daily in the purified liquid." (Allen Hazen in Rep. Mass. S. B. H. 1890 Pt. II, p. 567).

The action of the various layers of the filter in removing organic matter and bacteria is shown by the following analysis of sand at various depths from a continuous filter passing Merrimac River Water at a rate of 5,000,000 gallons per acre daily. (Report of Mass. State Board of Health 1894, p. 603).

Depth From Surface.	Organic Nitrogen. (Parts Per 100,000 Per Weight of Dry Sand).	Bacteria Per Gram.
0¾ inch	21.8	5,400,000
1 "	13.3	1,500,000
3 "	6.9	820,000
6 "	4.1	245,000
12 "	4.1	120,000
24 "	1.8	49,000
36 "	1.0	42,000
48 "	0.6	35,000
60 "	1.3	13,500

It was the writer's privilege to visit the Lawrence Experiment station in September, 1895 and I there saw sewage from the main sewer of the city of Lawrence, a city of over 40,000 inhabitants, being passed through about five feet of pea gravel at a rate of a quarter of a million gallons per acre per day, an effluent being obtained of sufficient purity to offer no offense if turned into a stream whose waters were used for any but drinking and culinary purposes, saw this effluent then passed through about five feet of sand very similar to our lake sand at a rate of two and one-half million gallons per acre per day and saw the final effluent of such purity that the assistants in the laboratory had no hesitation in drinking it, its composition being about that of the best spring water.

Owing to the wonderful success of intermittent filtration in the purification of sewage it was applied to the filtration of water and for extremely impure waters will remain probably the best method of treatment. The first filter constructed to work intermittently was that at Lawrence, designed by Hiram F. Mills, C. E., from the experiments of the Massachusetts Board of Health, although at Chemnitz, Germany, the principle of intermittent filtration had been utilized in connec-

tion with a well supply. Mr. Mills describes the Lawrence filter and the reasons leading to its construction in the Report of the Massachusetts State Board of Health for 1893 (p. 545 et seq.) from which is abstracted the following:

"The Lawrence pumping station is by the side of the Merrimac River, from which the supply is taken, above the city and about 1,000 feet up stream from the nearest house. The works have been in use about seventeen years. For some years after they were built—while a filter gallery parallel to the river of small capacity supplied the town—there was a diminuation in the number of deaths by typhoid fever from the number when well water was used, and no one thought of direct poisoning by sewage of the water taken from the river nine miles below Lowell with a fall of ten feet through a rapid a mile long on the way. Many made the remark that running water purified itself in a less distance and put away any fear of contamination, while a few did not relish drinking water into which the sewage of 70,000 people had been poured only eight hours before it reached the intake of the water works. However, in 1890 a careful study of the deaths from typhoid fever in the cities of the state showed that the cities of Lowell and Lawrence had nearly three times the average number as the same population in other cities; and that during the season—August, September and October—when other cities had the most typhoid fever, Lowell and Lawrence had about the same number of cases as other cities, but a month or more later the deaths in Lowell reached three and four and eight times the deaths in other cities, and after another month those of Lawrence increased in a still greater ratio, so that in some years the deaths in January and February from this disease were more than the actual number in Boston, with ten times the population. This condition, following year after year, made it so evident that the disease came down the river to Lowell from the towns above, and then came with greater intensity from Lowell to Lawrence, that the State Board of Health made strenuous efforts to produce a filter that would remove all disease producing germs that could be applied to it, and at the same time

filter rapidly enough to serve for a city's water supply. Billions of typhoid-fever germs were cultivated and applied to filters of different construction, and in 1891 we succeeded in removing all that were applied when filtering 2,000,000 gallons per acre daily."

Then the Board advised the city of Lawrence to filter its water and offered to show how this could be done. Such a filter would require some layers of quite fine sand, and it was thought necessary to first take out the very fine river silt from the water by means of a coarser sand filter at the river bank. Further experiments showed that the construction of a filter at the river bank with a sand coarse enough to allow the river silt to be depo ited upon it, if the silt were removed promptly, would serve to remove ninety-eight per cent. of all bacteria of the river water and a still larger per cent. of the disease producing germs; and considerations of economy and the immense advantage of such a filter, with the probability of this or none, with an unbelieving public, induced the State Board of Health to advise the city to immediately construct such a filter and save the fifty-seven lives which was the annual excess of deaths by this disease over the same number of inhabitants of cities of the state having a good water supply.

The top of the filtering sand was to be two feet below low water in the river, and could by a proper inlet be flooded to a depth of about two feet, thus forming a shallow pond of about two and a half acres in extent, which would gradually filter downward to the underdrains and be carried off to the pump well. One of the essentials of the design required that the inlet should be closed once a day and the water pumped out of the sand to allow it to fill with air. This condition of filling the sand daily with air was regarded necessary to insure burning up to nitrates the organic matter which penetrated the sand below the surface, thus producing conditions the most unfavorable for the continuation of the life of bacteria within the water in its passage through the sand and after leaving the filter. The underdrains were placed thirty feet apart consisting of glazed sewer pipe for about 0.4 of the way across and layers of different sized stones for the rest. The supply con-

duit was made of cobble paving stones four to six inches through, laid in Portland cement mortar on a layer of gravel and sand. The sand was deposited in ridges and valleys, the former being over the underdrains while in the latter the carriers were brought out from the supply conduit. These were built of rubble in Portland cement mortar on the sand and were made smooth inside. The sand varies from three feet in depth in the valleys to six feet in depth in the ridges.

The filter when completed required about ten days to get to working properly, but since that time marked chemical changes in the oxidation of albuminoid ammonia to nitrates and the reduction of color in the water have been noted, while 98.3 per cent. of bacteria in the river water have been removed, and by the oxidation of the organic matter depriving them of the means of existence a further reduction takes place so that at the tap in the city hall but 0.9 of one per cent. are found. The experiments of the State Board of Health go to show that with this result we can rely on the complete extinction of all of the disease producing germs that may have been in the water.

As to the results obtained from the filter, up to the period of its completion from 1872, the number of deaths from typhoid fever in Lawrence per 100,000 had exceeded that of any of our larger cities, even Chicago and Philadelphia falling considerably below. Every year as sure as the typhoid epidemic struck Lowell, so sure was it followed by a more disastrous one in Lawrence. During the eight months from October to May inclusive, from 1888 to 1893, the average number of deaths from typhoid were by months as shown in the following table, as is also the record of the same months since:

Months	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Total.
Ave. deaths per month for 5 years without filter	4.0	5.0	8.0	7.0	8.0	6.0	3.5	1.5	43.0
Actual deaths per month with filter 1893 and 1894	1.0	1.0	2.0	2.0	5.0	4.0	0.0	2.0	17.0
Of the deaths in 1893 and 1894 it was found on investigation that unfiltered water in the factories had been drunk by the following numbers	0.0	1.0	0.0	1.0	4.0	3.0	0.0	0.0	9.0
Leaving the deaths among those using filtered water	1.0	0.0	2.0	1.0	1.0	1.0	0.0	2.0	8.0

The filter appears, therefore, to have reduced the number of deaths from typhoid for the eight months from 43 to 8 or over 80 per cent. and through the courtesy of Mr. Wm. R. Copeland, Biologist of the Experiment Station, I learn that the total deaths for the whole of 1895 was only 16, of which 9 had been users of unfiltered water.

A further evidence of the efficiency of filtration in preventing disease is given by the experience of the German cities, Hamburg and Altona during the cholera epidemic of 1892, which is described by Prof. Frankland, (Micro-organisms in water p. 152 et. seq.) as follows:

"These two cities both are dependent upon the river Elbe for their water supply, but whereas in the case of Hamburg, the intake is situated *above* the city, the supply for Altona is abstracted below Hamburg *after it has received the sewage of a population close upon* 800,000 persons. The Hamburg water was, therefore, to start with, relatively pure when compared with that destined for Altona. But what was the fate of the two towns as regards cholera? Situated side by side, absolutely contiguous in fact, with nothing in their surroundings or in the nature of their population to especially distinguish them, in the one cholera swept away thousands, whilst in the other the scourge was scarcely felt; in Hamburg the deaths amounted to 1,250 per 100,000 and in Altona to but 221 per 100,000 of population. So clearly defined, moreover, was the path pursued by the cholera, that although it pushed from the Hamburg side right up to the boundary line between the two cities, it there stopped, this being so striking that in one street, which for some distance marks the division between these towns, the Hamburg side was stricken down with cholera, whilst that belonging to Altona remained free. The remarkable fact was brought to light that, in those houses supplied with Hamburg water, cholera was rampant, whilst in those on the Altona side and furnished with Altona water not one case occurred. The Hamburg water, however, to start with was, as we have seen relatively pure when compared with the foul liquid abstracted from the Elbe by Altona; but, whereas, in the one case the water was submitted to exhaustive and careful filtration

through sand before delivery, in Hamburg the Elbe water was distributed in its raw condition as taken from the river. But further testimony was afforded later to the truth of this interpretation; for during the ensuing winter, when the cases of cholera had almost completely died out in Hamburg, suddenly a most unexpected and unaccountable recrudescence of the epidemic occurred, and this time in Altona. This outbreak could not be traced to any direct infection with Hamburg, but must have arisen in Altona itself. In all, about forty-seven cases were recorded between Dec. 23, 1892 and Feb. 12, 1893. A searching inquiry was instituted and it was ascertained that the number of bacteria in the filtered water, usually about 50, had, during these months risen to as many as 1,000 and more per cubic centimeter, clearly indicating that the filtration of the water was not being efficiently carried out. That this was actually the case was proved by the fact that one of the sand filters, which had been cleaned during the frost, had become frozen over, and was in consequence not able to retain bacteria. That the outbreak did not become more serious Koch ascribes to the fact that this imperfectly filtered water was so largely diluted by that which had been efficiently filtered."

The first consideration in the construction of sand filters is to so design them that every part of the surface shall filter with the same rapidity. To accomplish this not only the resistence to flow through the sand is to be taken into account but also the friction in the underdrains. For best results it is also desirable to have an impervious bottom to prevent the inflation of ground water which often tends to increase the hardness of the effluent if it does no worse. The ordinary construction is to surround the underdrains with gravel and on top of this to lay the sand from four to five feet deep of uniform size, although some vary the size from fine to coarse downward, while in the Lawrence filter two sizes of sand were used, the coarser being on top, which would probably be an unsatisfactory arrangement in continuous filters. In operating care must be taken that the inflowing water does not disturb the surface of the filter. When the surface layer becomes clogged the water is drawn off and the surface is scraped,

removing the sand from one-quarter to one inch in depth, which is afterwards washed and may be reused. Usually about once a year, in English practice, the filter is renewed by removing and replacing all the sand, but the Lawrence experiments prove that filters are more efficient when undisturbed the fourth year than they were the first. (Report Mass. S. B. H. 1894). The scrapings are required usually from once in ten to thirty days. In European practice after scraping it is customary to waste the effluent of the filter for a few days, as it is found that more bacteria pass during the three days following scraping than at any other time, but the Lawrence experiments indicate that by working the filter for the first three days at a slower rate and by using a good depth of uniform sized sand the danger may be averted without waste. The usual rate of filtration with ordinary waters is two and one-half million gallons per acre per day. The observations of 1894 at Lawrence indicate that old filters may be safely worked at higher rates.

As to the cost of filters, that at Lawrence is one of the cheapest ever constructed, it being two and one-half acres in area in one bed and cost $67,000, or $27,000 per acre, but no effort was made to render the bottom impervious. In climates where freezing weather is of frequent occurrence or of long duration, filters should be covered, as frost interferes greatly with their efficiency, and as water flowing under ice is particularly liable to bear contamination and dangerous bacteria. (Micro-organisms in water, p. 147). The cost of continuous filters uncovered, ranges from $20,000 to $45,000 per acre, and for covered from $40,000 to $90,000. Mr. Hazen estimates for small filters an average cost of operation of $1,500 per annum per million gallons daily, but as a large amount of this is for superintendence, examination and testing, which would not increase at the same ratio as the size of the plant, this figure based on an 8,000,000 gallon plant seems large for a large plant. The Lawrence filter treating on the average 3,000,000 gallons daily cost for operation and maintenance in 1894 about $4,600.00 or a little over $1,500.00 per million, which shows the figure correct in this case.

No discussion of the subject of this paper could be complete without some mention of mechanical filters, which since 1889 have been coming into extensive use and have reached a sufficient degree of perfection to be adopted in such cities as New Orleans and Atlanta, and to be carefully considered in Minneapolis and Providence. These filters may be classed under two heads. Those which use coagulents and those which do not. In the latter class the water is simply passed rapidly through sand in iron cylinders and this sand is frequently washed with the filtered water. The same rules govern here as in slow sand filtration and as it has been found there that bacterial efficiency cannot be obtained at rapid rates of filtration, we have no reason to expect it in the mechanical filter under the same circumstances. We have excellent proof, in the experience of a Vermont town mentioned by Mr. Hazen ("Filtration" p. 107) where an epidemic of typhoid was caused by water previously passed through one of the leading makes of this type of filter, that they are unreliable. When, however, a coagulent is added to the water before passage through the filter, we have an entirely different case to consider. This coagulent, frequently alum, lime or a salt of iron forms a chemical union with the suspended and dissolved matters and precipitates them, by which process the bacteria are also carried down entangled in the sediment, or else the results of the combination remain in suspension in masses of such size as to be easily removed by the passage through the sand, even though at a rapid rate. In some recent experiments in Providence, water was treated at a rate of 128,000,000 gallons per acre daily with a bacterial efficiency of over 98.5 per cent. These filters have gained a considerable foothold from their lower first cost as compared with sand filters, but their use seems to be accompanied with much more risk than is the slower sand filter. The difficulty is that unless the coagulent is added in exactly the proper proportions to dispose of the foreign matters in the water, the excess if any is carried over in the effluent often producing as disagreeable if not as dangerous results as the original pollution, and if an insufficient quantity is used some of the impurities are carried over. As the impurities in water

vary from day to day, and sometimes from hour to hour, to secure the perfect action of such an apparatus requires an amount of judgment and skill rarely found in those who are employed to operate such plants. Moreover, a careless or sleepy attendant may fail to apply the coagulent at the proper time and a million gallons or more may thereby pass through without treatment and no one be the wiser until the health of the consumers bears testimony. In slow sand filtration it is different. If the filter is not properly cared for it ceases to deliver water at the required rate and thereby gives warning of its condition. At the same time the latter is too delicate an aparatus to leave to run itself and requires care and judgment in its operation. We shall, however, await with much interest the results of the Louisville experiments with mechanical filters which are now being carried on under the direction of Mr. George W. Fuller, who followed Mr. Hazen in charge of the Lawrence Experiment Station.

Household filters, unless properly cared for, are more often a source of danger than a protection against it. Mr. Hazen (Filtration, p. 116) says, "Those usually sold as germ proof, consisting of sand, animal charcoal, wirecloth, filter paper, etc., do not afford protection against any unhealthy qualities which there may be in the raw water. Animal charcoal removes color without removing the far more objectionable bacteria." In regard to the efficiency of the better class, Frankland (Micro-organisms in water, p. 172) experimented on a Pasteur-Chamberland Filter and found it, when new, to be bacterially perfect in efficiency, but in filtering filtered Thames water, it decreased its yield rapidly. Freidenreich carried on more extensive experiments with this filter, which as reported by Frankland (p. 174) showed that after six days' operation at a temperature of 35 degrees C. the filtrate contained bacteria. Whether dangerous or pathogenic bacteria can pass through this or similar filters has not as yet been determined, but if even these filters are used, the authorities say they should be frequently sterilized. But it occurs to the writer in view of Mr. Hazen's discoveries of the growth of bacteria in sterilized sand, recorded above, that it might not be impossible for a

similar action to take place under like circumstances in a Pasteur-Chamberland filter, so that frequent sterilizing might not be an unmitigated blessing. This is a point, however, that I have never heard discussed, but I am informed that the Pasteur-Chamberland filters used at the Columbian Exposition were never sterilized.

The President.—Gentlemen, you have this paper of Mr. Williams before you for discussion. I have the 18th and 19th Annual Reports of the Lawrence Water Board which contain some photographs and cuts of plans of those famous filters, and they are being passed around the room now.

Mr. Sears.—I feel personally thankful to Mr. Hazen and Mr. Williams for these interesting papers, or anything that will lead to the diminution of the sewage evil. I was thinking, as they are both good looking gentlemen, that I was sorry they were not talking to our wives and sweethearts, instead of to men. Here in this community—and I want to get out of it for that very reason,—you cannot stir up enthusiasm enough to secure pure water. These papers should be put in pamphlet form and circulated throughout the State so that the women can read them. They will stir the men to action.

Mr. Wells.—It occurs to me that it would be a good idea to incorporate these two papers in the Report of the State Board of Health. I don't believe they have had two such able papers as these.

Mr. Hazen.—Not being a member of your society, I don't know whether I am allowed to speak or not.

The President.—You have the freedom of this Society.

Mr. Hazen.—I was glad to hear what Mr. Williams said in regard to the mechanical filters. I did not take up the discussion of them last night because it is a subject that has not been thoroughly investigated as yet, and we are waiting for more information.

These mechanical filters were originated in the paper mills of New England; I believe the Cumberland mills, just above Portland, Maine, were the first to use them. They were devised to take out the particles from waters which would

injure the texture of the paper, and in doing that they have been eminently successful and have accomplished a great work in that particular field. No one recognizes that more fully than I do. It has been thought by many people that because they were successful in paper mills they would be equally good for filtering town and city supplies; but it needs but little reflection to show that the case is entirely different, and the particles which it is necessary to remove in paper manufacture are entirely different in size and nature from the organisms and properties in water which render it injurious for drinking, and because a filter is satisfactory in one case, we cannot argue that it will be successful in another. It must be judged entirely on its own merits in doing this particular work, and upon this problem there is not sufficient evidence, except that we do know that when alum is not used, satisfactory results cannot be accomplished.

The Providence filters, in regard to which Mr. Williams spoke, are said to have given in some cases a very high efficiency, and in other cases very much lower efficiencies, so that there seems to be some doubt as to whether the high efficiency could be depended upon in all cases. But as the results have not been published, and as we have only seen a part of them through the courtesy of Mr. Weston, the engineer who made the experiments, not much can be said upon the subject.

We shall, as Mr. Williams has said, look with great interest for the results of the experiments now being made at Louisville. It has seemed to us that until this subject is cleared up we could not afford to recommend a process about which so little is definitely known. We cannot as yet call the mechanical filters past their experimental stage.

At New Orleans the city refused to accept such a plant put in by a company, on the ground that the company did not fulfill its contract, and the court sustained the city, and the company is said to be bankrupt. So it was not an unqualified success in that case.

The sand filtration in regard to which we have been speaking is so well understood and has been so widely used that we

can speak of it with the greatest confidence, and can recommend it to the cities needing filtration. The cost of construction may be greater than the cost of mechanical filters, but the cost of operation is probably less. Under the circumstances we have felt that we were only justified in recommending that process to cities, and that we could afford to wait until more was known about the mechanical filters before recommending them.

Mr. Keeler.—I would like to ask Mr. Williams if he has any knowledge of the working of the filter plant at Mt. Clemens. They have a mechanical plant there with a capacity of about one million gallons,—used for domestic purposes and fire protection. They pump right along when there is fire without lack of supply. As to the quality of the water, I talked with some of the commissioners and they are very well pleased with it, but as to the scientific results, I had not learned anything.

Mr. Williams.—We sometimes have to resort in these cases, to analogy. I have no personal knowledge as to the results obtained from the filters at Mt. Clemens, but I do know this, that the people at Mt. Clemens are at present very anxious to get a supply of water from Lake St. Clair, and they have employed Mr. George H. Benzenberg, City Engineer of Milwaukee, to report upon the feasibility of obtaining water from Lake St. Clair, and I presume if they were satisfied with the present system, they would not be looking for a supply at such a distance.

Mr. Keeler.—The reason they are looking to Lake St. Clair is, I believe, because the river is failing. They are afraid they will be shut off on account of the lack of water in the river.

Mr. Wells.—Since we have had the practical application of electricity, people have grown into the habit of thinking they can do business at long range. I do not think this is so in the matter of examining water supplies. The only way to court the acquaintance of the bacteria is to get right on the ground, where they are, and cultivate an acquaintance at close range. The company with which I am connected has had some

experience, which shows to what extent a wrongly conducted examination can be injurious.

On one plant, in which the difficulty with the water supply has been very great, the borough brought suit to have the contract anulled. It was a case in a Court of Equity, and the borough had one of its councilmen take a jug, whose history was unknown, and gather up a sample of the water, and send it to an employee of the State Board of Health. The young man made a chemical analysis of it,—found 503 solids in a million parts, and very readily condemned the water. The truth of the matter was, that there were over 200 parts of those 500, which were salt,—and he also condemned it on account of the sewage contamination I believe. The truth of the matter is that salt is a mineral there, and of course is not injurious to the health. The young man admitted on the stand that his process of reasoning was not regular, but still it had a great deal of weight with the court, and the contract was annulled.

Now if that man had gone on the ground,—had examined the territory from which the supply was taken, he would necessarily have had to make a very different report.

Mr. Williams brought out another point which I find is contrary to common belief,—that you can not sit down in the committee room of a council chamber and write out a standard of purity which shall be an entire protection for the public. I have had to contend with that old idea a good deal and I am surprised at the places where I find it supported by people asking for standards of purity.

In one case, a member of the State Board of Health insisted upon a standard of purity. It was in this same case where the salt was found, and I believe 20 parts salt in 100,000 are allowable, are they not, Mr. Hazen?

Mr. Hazen.—I think the only limit to that is where the salt is tasted.

Mr. Wells.—Some of the old standards of purity put it at 20 parts, I think.

Mr. Hazen.—Oh yes,—the limits placed were often even lower than that.

Mr. Wells.—This physician of whom I speak, was ready to adopt the salt limit of these old reports, which have been widely published—and in a case where the salt was clearly a mineral, it would have thrown out water that was otherwise good.

Mr. Roberts.—In a municipal convention at Cincinnati, last October, Mr. John W. Hill of that city read a paper on pure water, and in the discussion, he made a comparison similar to the papers of Mr. Hazen and Mr. Williams, of German cities, and in the discussion, the question came up as to whether it was really fair to compare the death rate of typhoid fever in American cities with German cities, because so much less water was drunk. He then gave some statistics in regard to beer drinking in American cities. But few would imagine that the total consumption of domestic beer in the United States amounted to 33,000,000 barrels during 1894; it is in the principal cities, however, that the largest consumption occurs, and from imperfect statistics,—although at the present time the best obtainable,—the local consumption is given as follows:

In Boston, gallons per capita per annum	65
In Cincinnati, " " " " "	80
In St. Louis, " " " " "	98
In Milwaukee, " " " " "	105

In Munich, (considered the largest beer drinking German city), the annual per capita consumption is 128.

Mr. Sears.—Where did they have the least typhoid,—where they drank the most beer?

Mr. Roberts.—It appeared so with the German cities.

Mr. Wells.—I wouldn't be surprised if the statistics would show that water had killed more people than beer and whiskey. Frances Willard though, would show the other way probably.

Mr. Appleton.—Very few people have been drowned in beer.

Mr. Rogers.—I have seen it stated in a paper by Col. Waring, that typhoid fever is really a disease of the country rather than cities and towns; take it the country over, and there it is largely traced to the water supply.

Q. You mean the country regions?

Mr. Rogers.—Yes. Country population. I would like to ask Mr. Hazen if that idea is well founded.

Mr. Hazen.—I think as a rule, that country districts and smaller country towns have higher death rates from typhoid fever than most cities, and that is commonly attributed to the use of well water. That is a subject which I have not studied in any great detail, as my work has been confined almost entirely to cities.

Mr. June.—In this connection I have noticed that as it has repeatedly been intimated here, typhoid occurs after a drouth, and when there is a dry season, the next winter typhoid fever prevails in the country districts; if there is any further light on that subject,—how the water becomes contaminated—or whether the cold weather is favorable to it,—I would be very glad to know about it.

Mr. Weatherwax.—Can anyone explain the cause of the epidemic in Duluth, where they take their water from Lake Superior, supposed to be the best water in the world?

A. They dump their sewage into Lake Superior just above the city.

Mr. Roberts.—A former resident of Saginaw informed me that the sewage disposal of Duluth was less than a block distant from the water intake.

Mr. Williams—In regard to low ground water and its effect on typhoid fever,—the subject has received some attention; I have had no opportunity to make any original investigations, but the amount of it seems to be this, that where people are dependent on a well for their water, the conditions will ordinarily be observed, that when you have low water,—a drouth,—the water is drawn down low in the wells, and then when the fall rains come on, they will be followed by typhoid; it is possible to explain this on the ground that the substances gathering on the surface, in case of a sudden rain, are washed down into the wells. We have the same thing in the filter. When you start the filter new, it does not retain the germs. Only after it becomes saturated and the bacteria established, does it do good work. So with the ground,—when it is thoroughly dried out, and suddenly treated to a heavy fall of rain,—the great proportion of the substances gathering on the surface, are carried down into the wells.

It is peculiar, as I stated last night, that in the experience in Massachusetts, where well-water supplies are comparatively unused, and the public supplies are mainly drawn from very large reservoirs in which the water remains for a long time before it is used,—or else are taken from deep wells,—that they do not find that this condition exists. Taking the Statistics for fifteen years, they find that the prevalence of typhoid fever has been no greater following long drouths, then following wet seasons, while in the State of Michigan, our State reports bear out closely the theory that typhoid fever is associated with storms following low ground water.

One of the oldest physicians in that part of the State, with an experience covering thirty or forty years, in and about Detroit, said he had learned to look for typhoid to make its appearance after a long drouth, and the more prolonged the drouth, the greater the prevalence of typhoid.

That is not to be taken as an argument against the statement I have made, because Detroit's water supply is not to be compared with the supplies of Massachusetts. Detroit's supply receives, as do the wells, the washings of sudden rains from a drainage area which is tributary to Lake St. Clair and Detroit River, so close to Detroit's intake, that the material washed into these waters and on into the Detroit River, it is entirely possible may pass through our intakes, and though in Detroit, out of a population of nearly 270,000 people I do not think there are three thousand people who are dependent on wells for a water supply, this condition will be found to exist there and will bear out the Michigan statistics, taken from those places where well supplies are used, but will, when studied into thoroughly, corroborate the Massachusetts report.

Mr. Sears.—I think typhoid fever is occasioned greatly by the proximity of the privy vault to the well.

A. It might be so in case of a limited area, as a city lot, but it is rarely the case in the country.

Mr. Hodgman.—There is a question I am interested in. How much protection is sand against the infiltration from privy vaults or from the surface? Mr. Williams spoke of the depth of the water. How much sand ought there to be above

the surface of the water to filter the water before it goes into the well,—if any amount will do this,—how much?

Mr. Williams.—It is a question where to locate that limit. Mr. Hazen perhaps will speak on the subject more authoritatively than I. It has been found, in the operation of filters, that if you filter to-day at a slow rate and to-morrow at a high rate, you destroy the efficiency of filtration. It must take place at a uniform rate. And so the point comes right here: If the filtration from your privy vault is going on at a slow and even rate, through sand,—if your rainfall is evenly distributed, and the sand kept moist, it is perhaps possible that it might be safe with no more sand than we have in the filter bed. It is possible to purify sewage by passing it through five or six feet of sand, but the conditions of the ground are conditions that you cannot control You never know what you are getting, so it is not safe to bring a well in very close proximity with this source of contamination. You would better keep the vault a good distance away.

Mr. Hodgman.—That very question was the source of quite an extended law-suit in my vicinity. It went to the Supreme Court of Michigan and they fought it for all it was worth.

A man purchased a place in proximity to a cemetery—perhaps 25 rods distant. The town proposed to make an addition to the cemetery and he undertook to prevent them from so doing, (he was a physician) on the ground that it would be a damage to his water.

In that case, in the way of testing it, they put into a well, at about that distance, some aniline colors for the purpose of tinting the water and found that it did tint the water in his well, and in that case, the water was from 25 to 30 rods away.

Take it where I live, we have a surface soil of loam from one to six feet in depth, and underneath that is nice, clean sand, clear down to the water. In my own well, the water is 32 feet with probably 26 feet of nice, clean sand on top.

The physician in that instance lost his case, because they said he bought his lot with the cemetery there, and that the addition would not hurt him any.

My property is next to a school property, and they have privy vaults there that go down as far as the sand, and they are at a distance of ten or fifteen rods from my well. The question is, will it affect my well where it must go through 20 feet of sand and then travel that distance?

Mr. Williams.—In all this discussion, there is one point we have lost sight of. In the purification of water, air and the presence of certain organisms are necessary. These organisms have been separated and identified at last, but their habits and the conditions under which they live have not been entirely determined. It is possible they might not be able to live ten or twenty feet below the surface, while they might be able to live in the filter. If I had the case of a well and privy vault within 20 feet of each other, I would not want to drink the well water very much. I would try hard to find something else to drink.

Mr. June.—I have such a case as that, and I have abandoned the well. I think that is the safest way.

Mr. Sears.—I would like very much to hear some comments from my friend, Mr. Webber, on this subject.

Hon. Wm. L. Webber.—I have had no such experience as would justify me in speaking, after the papers that have been presented to this convention.

I will say this, however, while I am on my feet. When the water supply for this side of the river originated at the site of the present water works above here, an attempt was made to filter the water, and filtration was provided by procuring a very fine gravel and sand of various sizes, and quite a field for surface filtration was provided. It operated very nicely until the gathering of sediment spoken of last evening by Mr. Hazen, prevented the water flowing through with sufficient rapidity to supply the works. Then an attempt was made to take off that sediment and wash it, and bring back clean sand in its place, and so change from one layer to another. After an effort of two months in that direction the amount of labor and expense involved proved so great, that the filters were laid aside, and the water was permitted to flow through the pumps without any effort at filtration.

I have been much interested in the remarks concerning the apparent chemical effect of filtration upon water. From what I had learned, I had been led to believe that the poison which produces typhoid fever and diphtheria could not be detected by a chemical or microscopical examination. That about the only way to tell it was for some one to drink it and die, and that was pretty good evidence that it was there.

Now of course we are all familiar with the effect of oxidization on sewage which runs along an open stream. Some of the streams in England, I am told, where there is a large amount of impurity thrown into them, after a flowage of 15 to 20 miles, particularly if they run over a pebbly bottom at a pretty good rate of speed, are considered innocuous, but I learned last evening, for the first time, that the effect of mechanical filtration was to remove the qualities from water which would have rendered it unhealthful.

Of course we know it will take out the mud and leaves, but it won't take out the stain from pine logs; it will take out part of it, so that it does not look quite so dark colored.

Dr. Kedzie, who was once President of the State Board of Health, says that the juice of the pine log is not unhealthful; he does not consider our water any the worse for having the pine logs soaked in it. We had that question under discussion at a convention held at this city, but I will not take up your time further because you have your own things to talk about.

I thank you gentlemen, for your attention.

IRRIGATION ENGINEERING.

BY L. G CARPENTER.

Irrigation engineering in the United States has been a development of the last twenty or twenty-five years. In that time, the conditions of western progress have required the construction of thousands of canals and the expenditure of millions of dollars in order to bring water to apply to lands for agriculture. When confronted with the question there was little to guide the engineer and it has been largely a natural development from experience in the United States. The combined European experience was not accessible to any great extent and it is probable that very few of those who have been instrumental in the development, have known, or had the advantage of the lessons from European practice. Under the conditions, many mistakes, grievous and costly, could not but be expected. They are found on all sides. The wonder is that under the circumstances, more have not been made. The problems to be met with in irrigation engineering are many of them such as require a complete grasp of the laws of the movements of water, and it is true today, as it was centuries ago, that the laws of water are both complex and difficult to understand. The acute Galileo was forced to exclaim in despair that it was far less difficult for him to determine the laws governing the heavenly bodies which were at a great distance than it was to determine those of water which was close at hand. It has been the case in the past that anyone who could run a level has felt competent to lay out a canal, but nothing is farther from the truth. Many canals have been failures in operation because of the unskillful location and the lack of knowledge of the conditions governing a canal and irrigation on the part of the original engineer. When once constructed, a change is costly and requires urgent reasons to modify the location. Nevertheless, many canals have been rebuilt for large distances in order to correct the

mistakes which should have been avoided in the original location. It is true in this as in other engineering, that many faults in construction are not entirely due to the engineer, but to the conditions under which he was forced to work. It is impossible to free him from all blame, though the promoter or the persons who furnish the capital should have a great deal, and in some cases all the blame.

The character of the engineering has been typical of American engineering in general, inasmuch as it has been such as to economize first cost. This leads to greater expense in maintenance, but the necessities of the case have been the same as in other American engineering. The development would not have been possible without a saving of the capital cost and of interest charges. The structures are almost always therefore, of timber, often crude and in reality often very expensive. They are not, in consequence, ones that the engineer will point to with pride. The types have developed under the stress of conditions. The best type of structures to meet the conditions has not yet been agreed upon. A trip over the most successful canals would show structures usually crude and not such as one would usually care to show in a photograph, and those which are frequently shown as examples of irrigation engineering practice, as in the so-called "Engineering results of the United States Irrigation Survey," are mostly structures from enterprises which have been failures. It may be said that the use of temporary structures may be considered as a stage in development. As soon as these enterprises become firmly established and when the communities are willing to pay something to get free from the annoyance caused by poor structures, permanent construction will be adopted in place of the present structures. This is becoming the case already in Colorado as the present structures of wood decay and need to be rebuilt, many are making structures of stone and iron, and more will do so within the next few years.

Notwithstanding the criticisms that may be made upon the engineering, yet as a whole, it may be said to be creditable to the engineers connected with it. While the structures themselves do not compare in solidity, in finish, or in detail, with

those of European and Indian canals, yet it may be said that the European engineers have not been free from serious blunders as well. Water is an exceedingly difficult element to manage, and under the conditions to which it is subject in irrigation, the constantly varying amounts of water, the varying amounts of silt, a great degree of refinement is out of place. But it should certainly be expected that the engineers on such work should at least be acquainted with the elementary laws of hydraulics, and should know enough of the conditions of irrigation to have some conception of the way in which the canals will in future be used.

I have spoken above of canals, but it should not be understood that irrigation engineering is confined to canal work. It involves much more than this and should really include all the questions involved, from the question of water supply and its development to the delivery of the water to the consumers.

One of the first questions to consider in an irrigation enterprise is that of water supply. Priority of right is recognized throughout irrigation states. The first canal which is built has the first right to the water. This may be an absolute or a limited right, sometimes a conditional one. If the enterprise is to take water from a stream already supplying canals, the extent of the rights and the amount of the water remaining after their rights are supplied need to be known. Were this investigated some of the enterprises which have been undertaken would not now be started, to the regret of the stockholders. The water is needed more largely during one or two summer months and to a less extent late and early in the season. With the development of the country, it is probable that means will need to be provided to maintain a nearly constant supply of water throughout the larger part of the season. Where the supplying stream is a varying one, as in most cases, it may need to be supplemented by storage reservoirs or other means of maintaining constant flow. In Colorado a water right which is taken to supply sufficient water for eighty acres is based upon one to 1.44 cubic feet per second, constant flow throughout the irrigation season. This, it may be said, is not too much for about a fortnight at the time of greatest need, while for the rest

of the season it is far more than is needed. This is at the rate of from 55 to 80 acres per cubic foot per second. The net consumption of water is, however, at a much more economical rate, so that actually from 100 to 200 acres may have been irrigated during the season from the constant flow of one cubic foot per second.

Sometimes the statement is made that the duty of water is as high as 400 or more acres. It should be understood that with the same amount of water actually used we may obtain almost any result we please in the duties of water, depending on the time which the water is supposed to run. In all cases, the user does not want the water uniformly distributed, but wants the larger portion of it within a comparatively short time. In consequence if this large figure be taken as a basis for the water rights, some one is bound to be greatly disappointed.

In canal location, topographical features of the country may furnish governing points. Sometimes the canal is to be built to furnish water for a certain tract of land. Its size needs to be determined and the size depends upon the grade. The grade selected should not, properly speaking, be a constant grade, but should vary so as to maintain the same velocity, or else vary so as to change the velocity to correspond to the power of the soil to resist erosion. The velocity desired should also be such as would prevent a deposit of silt in the canal. Experience shows that the velocity can be kept enough to carry the silt through the canal to the land, both to the benefit of the land and the saving of cost of cleaning for the canal. This velocity should be usually from 2 to 5 feet per second. Some times greater velocities are allowable but they should more frequently be below this velocity than above. In most soil the upper limits would be destructive.

The formula used for computing the amount of water carried by canal is that of Ganguillet and Kutter. This is awkward to apply when the formula is used without the aid of tables. It is the best of the formulæ by all means. Its results cannot be implicitly relied upon nor is it probable that any formula can be produced which will not be subject to errors almost as great. The difficulties are inherent in the nature of

the movements of water which cannot be grasped by an equation.

A canal for irrigation has a different function from one for drainage. It is intended to carry water to be distributed over the lands and therefore it seeks the ridges for its location while the drainage ditch seeks the depressions. After leaving the stream, the canal will follow the flanks of the valley and finally may reach the ridge of separation between water courses and may then have to follow this ridge. If the grade is too steep, drops may be required to prevent washing. As compared with a railroad, the latter is flexible vertically but rigid in plan. A canal is flexible horizontally but it cannot vary vertically from the contour line, except in depression.

The canal is usually located in ground with a transverse slope, and it may, therefore, be entirely an excavation or partly an excavation with soil forming the lower bank, or it may be entirely in soil Whether the canal is deep in the ground or not should be regulated by the function of that portion of the canal. If water is to be distributed, then the canal should be shallow so that water can be applied to the surface close to the canal. If this section is used for carriage of water, then it can be placed deep in the ground. Also as the canal passes depressions or points, it may be placed shallow or deep. In the former case the force of the current is away from the artificial bank and in the latter case, the tendency to wash is protected against by the greater depth in the ground. Side slopes are usually made one to one in excavation and one and one-half to one in fill. A berme is not always used but it is an advantage and is well worth using. In the course of a few years' use, the canal washes out in places and the banks become nearly vertical. The berme is a protection to the artificial bank. Some times a sub grade is used and it is an advantage. In this case, the bottom of the canal instead of being level, is made deeper at the center so that with small quantities of water, there is less wetted perimeter, and the location of the current is practically controlled by the cross-section. It is also a question if this idea should not be carried further so as to attempt to control the current at the curves and anticipate the

changes which will take place during the course of a few years' erosion. When a grade of the water surface is determined after the canal is built and filled with water, it is not found to be parallel with the original bottom. Curves and contractions in the cross-section will cause it to vary.

Ravines may be crossed by means of flumes or siphons. The flumes are almost invariably of wood mounted on trestling, much the same as railroad trestling. The same principles of construction would be applied. The flume is intended to carry water and is subject to severe conditions inasmuch as it may be dry for a large part of the year. The alternate wetting and drying is severe on the best of construction and the leaking which may take place is damaging, not only because of the loss of water, but because of the risk to the ends of the structure. The points which need special protection in the case of a flume are the ends connecting with the canal so that the water may be brought into the flume and taken out without washing. Iron flumes will doubtless be used more in the future than in the past. Only two or three have been built in the United States. I have seen them in Algeria and in other foreign countries that have been in use for a number of years. In their case an additional difficulty is to provide for the expansion and contraction of the flume and still preserve a water-tight joint. Siphons, by which we mean inverted siphons, are used to a greater extent, and they may in time very largely displace flumes. For small quantities of water and under small heads, I have used ordinary sewer pipe with cement joints. For large heads, wooden stave pipe is being very largely used and has the advantage of cheapness and flexibility and of being constructed in place. Some of these siphons have been built to stand a head of several hundred feet.

The dams in the river or stream may be either a diversion dam or a lifting dam to raise the height of water so that it can be brought to a given level. The conditions for these are evident without description except to say that on sandy streams, the diversion dams are best constructed oblique to the current of the river. In very sandy streams and those subject to

floods, temporary dams of stones and brush are both cheaper and more easily maintained than the more costly ones.

The headgates are among the most important structures on the canals in size and cost. They need to be constructed so as to regulate any amount of water taken into the canal at all stages of the river, to be capable of obtaining a great deal of water at low stages or entirely shut out the water at high stages. The gates need to be capable of management by a minimum number of men and to be certain in operation. As some of the canals are 60 feet broad, and capable of carrying from 7 to 10 feet of water, it is evident that these structures need to be thoroughly made and strong Provisions to dispose of the sand that may enter the canal are necessary in many cases. In some streams sand is very bad and if allowed to enter the canal may cause a very heavy expense for cleaning. Where the canal is favorably located, the sand may be very largely kept out by the construction of a suitable headgate or by provision in the dam or sometimes by the construction of subgrades for the first mile of the canal with suitable waste gates deep below grade which can be used to flush the sand.

Storage reservoirs become an important feature in many of the enterprises. One such dam forms a lake of over 8,000 acres. There are many in Colorado covering from 2 to 800 acres and with depths from 20 to 50 feet. Within twelve miles of the town of Fort Collins where the Agricultural College of Colorado is located, there has been over a million dollars invested in the construction of reservoirs during the past eight years, and this almost entirely by the farmers by voluntary assessment. The dams are almost entirely dikes of earth. In some cases in the west, masonry dams are built, but usually the conditions are favorable to the construction of earthen dams.

A question which naturally comes to the minds of those present is doubtless whether the system of irrigation might be applied in Michigan, and whether it would be profitable to do so. With a fair knowledge of the conditions of Michigan, acquired from having spent most of my life there, and having had occasion to investigate the conditions and possibilities of

irrigation, both as applied in the west and in other countries, I may say that I think there is every reason to believe that irrigation would be a profitable improvement in the agriculture of Michigan wherever it can be used. The conditions are in many cases not favorable. But wherever the conditions are favorable—the streams with sufficiently rapid flow and so located that water can be derived from them by means of canals—the practice would be beneficial and would be profitable to those who undertake it. In how many years of farming under natural rainfall, does not the profit disappear because of the losses due to drouth or from lack of moisture at some critical period in the growth of the crop. Irrigation becomes an insurance against losses and enables the farm to be kept to its maximum productiveness. It may be said that with the rainfall in Michigan irrigation is not needed. The rainfall is over twice that in Colorado, nevertheless it is less than the rainfall in northern Italy, where irrigation has been applied for time unknown and extensively applied for at least eight centuries. In the valley of the Po, the amount under irrigation has more than doubled since the middle of the present century, and schemes are projected which will bring large additional areas under the influence of irrigation. Wherever it is practiced, the amount of land under cultivation by irrigation is constantly increased.

The most serious difficulty to be met with in the Eastern states is the trouble that may arise between the persons who desire to divert water for irrigation, and riparian owners, or owners of mill rights, whose privileges may be interfered with by the diversion of the water. The passage of favoring laws would remove some of the difficulty, but not all, inasmuch as the courts are likely to maintain that the rights are vested and cannot be disturbed by legislation.

The President, Mr. Wells.—This paper involves a good many problems beside the one of irrigation, and is one which ought to call out quite a full discussion.

Speaking of the formulæ for the flow of water and the difficulty of understanding them, I have had a little experience in

that line during the last four or five years, as my work has been largely in the line of hydrulics. Most of the formulæ are empirical, and are simply shrewd guesses. I have spent considerable time in comparing the various formulæ and I have found in my practice, the tables in Trautwine's pocket book of the edition of 1893, about an average of all of them; I started using them when I first went into the hydraulic work, and thought I would work out a formula for myself, but these I have laid aside for the tables.

Trautwine's son has changed the formulæ on which his father's book was constructed, but I am still of the opinion that that is a fair average. Simpson's is also a good formula.

Mr. Rogers.—There is quite a change between Trautwine's new formula and the old book, is there not?

The President.—Quite a change in his co-efficient. He gives an extended table of co-efficients which can only be grasped after considerable study.

Mr. Rogers —I think it materially reduced the quantity of water that will flow through a pipe of a given size.

The President.—The old co-efficient as I remember was 54, and he has run down to the twenties and up to about sixty.

A Voice.—He has become a more scientific guesser.

The President.—As to the rainfall which Prof Carpenter speaks of, I have looked that up a little, in Pennsylvania.

I think that the rainfall for a decade, say, is quite even in any given locality, but you take the rainfall for one year with another, and you are apt to have more than you want some years, and less others.

The five years preceding this, at Du Bois, Pa., which is near the summit of the Alleghany mountains, the Government Observer there showed me his reports within the last three weeks, and the average rainfall for those five years was 44.1 inches, and on the 16th of December, I think it was, the rainfall for this year had been 31.61—nearly one-third short. We have had a gravity system of water works there, and we have had to pump seven months this year.

Mr. Sears.—44 inches in Michigan?

The President.—No, sir! Du Bois, Pa. The rainfall there is somewhat greater than in Michigan.

Mr. Sears.—I have a little garden. Last summer, I planted a small area in corn, about a rod in breadth and two rods long. On the morning of the fourth of July, my corn was drooping, and instead of going with the crowd and shooting off fire crackers, I thought I would shoot my hose. I went to work and made a little trench in each row—a sort of trough—and laid my hose on that and let it flow about fifteen minutes over every row; you ought to have seen that corn prick up its ears at once! I don't know but I robbed the city slightly, but it demonstrated to me the value of water in the warm weather of summer. I think you could quadruple the crop.

In leveling across the valleys of Missouri and Iowa, I learned this fact. You leave the bluff and go down into the main valley, and you will find a marsh, maybe 100 rods wide, and as you approach the stream you get on higher land, and near the main stream you will find it covered with timber, and perhaps find the land three to five feet higher than near the bluff. The stream is on an elevated plain and then changes its course, and near the base of the stream, builds that valley up. The Mississippi today is on an elevated plain, and by building these levees, you raise the river bed and when a flood comes, there is destruction far and wide.

Mr. Hodgman.—Isn't that general principle true of the rivers of Michigan?

Mr. Sears.—Yes, sir.

Mr. Hodgman.—I have talked to this Society ever since I came back from the west, that irrigation was a practical thing in Michigan, that it would be profitable in many instances, and the last two or three years of drouth in Michigan have emphasized the fact considerably.

As large a per centage of the land in Michigan as in Colorado, Utah or the arid region, is capable of being irrigated, and this subject will in the future occupy to a great extent the attention of the people of Michigan. They are going to irrigate.

Prof. Carpenter has discussed the manner of irrigating by

canals, and has incidentally spoken of storage reservoirs. Right there lies the solution of the irrigation question in Michigan.

There is a large amount of upland that you would say at first sight, could not be irrigated, that could be irrigated if we will impound the water. Will it pay to do it?

I have a little place of about ten acres, and there are two or three hollows in it. Last March the water came down and in the deepest hollow, there was water six feet deep. Then the dry season came on and ruined my crops. If I could have had that half acre of water that went to waste, to use in the summer, I could have saved my crops.

Let us utilize the streams as far as we can; next, build impounding reservoirs, and use them as far as we can.

In the west, a good deal of land is irrigated by wind mills. They dig a well, put in a windmill and set it going. A man from near where I live, has a large tract in California which is irrigated solely by wind mills. I don't know how much of that is practicable in the State of Michigan, but there is no sort of question that it is possible to a certain extent. It is simply a question of dollars and cents. Will it pay?

Another thing, we have in Southern Michigan, and perhaps all over the State, a large amount of what we call "swamp land." The last few years have proven that this is the richest land in the state, but that it wants not only drainage, but also irrigation. They must go together. You can drain out these swamps to such an extent that they will be of little value, but if in connection with your drainage, you fix it at the same time so that you can stop the water and wet the land, then you have the ideal conditions.

One member of this society wrote me this winter, that last year he spent five weeks designing a drainage system for A. M. Todd, the Peppermint King, who has bought several thousand acres up in what is known as the Clyde Swamp. I went there myself once and I never want to go there again.

Judge Severens of the United States Court, bought something over 5,000 acres of land and I made the surveys for him. He has brought a large amount under cultivation and last year

he had something like 10,000 pounds of peppermint oil and ten thousand bushels of onions off of this swamp land.

Mr. A. M. Todd has purchased a large amount of this peppermint land and O. H. Todd is putting in an irrigation system for him. It strikes me that the irrigation of the State of Michigan is work for the engineers to do, and work that will be valuable to the people of the state.

Mr. June.—What is the condition of the swamp lands after they have been drained—are they too dry?

Mr. Rogers.--Unfortunately I have not been, for the past four or five years, through the lands where I did so much work—not since the drains have been in successful operation. As far as my observation goes, where the muck was deep, the drains have made it so dry that the lands produce almost nothing. Where the subsoil was clay, and the clay turned up a little with the plough, they have not met with this difficulty; if there were any way of damming the ditches, it would be of immense advantage, but the trouble with that land is that a large portion of it is nearly level. Some of these ditches are laid with a fall of only two feet to the mile, and if you attempt to dam them, you are in danger of completely spoiling the land you are trying to reclaim. The land is too level there for this to work.

Mr. Hodgman touched upon a point of which I had been thinking; whether it would be possible to irrigate with wind mills. There are many farmers throughout the state who use wind mills for pumping water for their stock, and they are not run to anywhere near their full capacity. If they had wells with capacity to run these mills longer, and could arrange to use the water to irrigate their farms, I think it would be advantageous.

Mr. Sears.—The only way to prove that would be by experiment.

Mr. Wells.--Between Saginaw and Bay City are some tracts of land of considerable extent which have been dyked, and from which the water is pumped. My observation has been conducted from a car window mostly, but I imagine they have been flooded considerably; but last summer I saw a very

simple contrivance, on the plan of a centrifugal pump operated by a portable engine, and they were pumping water out of the trenches onto the ground. There are probably some gentlemen who live here in Saginaw who have been connected with these improvements.

Mr. Holmes.—I have had no experience in the work of reclaiming land, as an engineer, although I am familiar with this method of reclamation. In one instance, the proprietor was not an engineer, and I think the contractor who did the trenching, wrote the specifications. All that was done was simply to throw up a dyke, and then pump out the water, and the reclamation seems to be complete and satisfactory. There was one place where it was unusually wet and we laid tile, and it was very efficacious in the removal of water.

Mr. Hodgman.—I want to say a few words in regard to the point raised by Mr. Rogers, in regard to these flat lands. Nearly all the celery lands in Kalamazoo County are that flat kind of land. They irrigate there almost entirely; they dam up their ditches when it is dry enough to need it and let the water flow back in the tile drains, which lead into the main ditches, and in that way the water is distributed.

The fact that there is little fall is not an objection to irrigating these flat lands. It is sub-irrigation.

The President.— Mr. Holmes, have you made any observation as to the extent to which this method of irrigation has been employed between here and Bay City, and with what degree of success the enterprise has met?

Mr. Holmes.—No sir, I don't know anything about that.

Mr. Hodgman.—Nearly all the flat lands in our vicinity—and there are many of them—are irrigated by stopping up the ditches and sending the water back. It is not surface irrigation, it is sub-irrigation. The largest crops we have had for years were raised there this past year, when on the uplands crops were very light. A neighbor of mine had 175 baskets of corn to the acre on the low land, while on the upland he didn't get 40. Supposing in that case I spoke of, that I had a reservoir that filled up in the spring and had a pump there, attached to an ordinary traction engine, wouldn't it have been practica-

ble to irrigate my land? Or would the expense have been so large that it would not have paid?

Mr. Wells.—The expense of lifting water at these low levels with a centrifugal pump is slight. There has been a pump used to a considerable extent in the South, with which they raise water ten feet, and the horse power is so small that the expense is very slight. The question of impounding water in such shallow depths, must be figured on with due regard for evaporation; it can best be stored in the deepest hollows. If a little damming of the outlets would tend to raise the water, it would pay to do that. On warm days, the water evaporates about ⅛ of an inch per day, in shallow ponds.

Mr. Hodgman.—That is a general guess I suppose.

The President, Mr. Wells.—Trautwine's observations are actual, but it would be subject to such varying conditions that you would perhaps hardly find another instance just like it, though that seemed to be a good average. He mentioned some specific cases in which this was so, and I think those were in some states further south than this.

Mr. Hodgman.—Perhaps Prof. Vedder can tell us something about irrigation at the Agricultural College.

Prof. Vedder.—I know very little myself, in regard to the matter. The experimental part is at the water supply end, but I have no question that it has cost more than it is worth to raise the water there.

Mr. June.—I am convinced that the cropping scope, as you might say, of irrigated lands north of Saginaw, would be about divided by two, from the fact that it would be necessary in my judgment, to raise only the crops that would resist frost. That the frosts are much worse on the low lands is well known and my observation has been that wherever crops have been placed on the low land, and were crops that would suffer from frosts, they have been destroyed. In the low lands which I have drained, the crops which succeeded were crops that were not easily injured by frosts; this would exclude, to a great extent, corn from these lands. If the higher land could be irrigated, by storage or any means, of course our season would

permit of a greater range of crops, and perhaps a great deal more profit.

In regard to the question I suggested to Mr. Rogers, in regard to the drying of the lands—the low lands—my observation has been that the ditch only dried the land to about the depth of the ditch, and the lands would draw the water still, but that was only in certain cases where the land was what we termed springy—it was deeper muck and more water on the lands, and the ditches only drained the surface of the land. Of course in an excessive drouth and in more cleared up country, the sub-irrigation idea would be splendid, but in the northern part of the state, I think that about half of the crops would be excluded.

RIPARIAN RIGHTS.

BY HUGO P. GEISLER.

Mr. Chairman and Gentlemen of the Michigan Engineering Society:

I was requested by the secretary and members of your Society, to read before you a paper on the riparian rights of property owners respecting the location of their boundary lines.

I beg to thank you for the honor you have thus done me, and shall endeavor to present such facts bearing on the subject as I hope may prove of interest to you.

Perhaps there is not a more difficult question to answer in all the law of real property. The English common law rule was that all streams, in which the tide ebbed and flowed, were navigable streams, and all the others were non-navigable.

3 Washb. R. P. 413.
People vs. Tibbetts, 19 N. Y., 523.
Commonwealth vs. Chapier, 5 Pick. 199.

In England this is not, as a matter of fact, the arbitrary rule which it would be, if applied without qualification to the streams of this country. With the exception of the Thames, above tide water, there are no important streams in England which are practically and actually navigable, except those in which the tide ebbs and flows; and there are no tide water streams of any importance which are not actually navigable.

But in the United States the situation is altogether different. Here we have fresh water streams which are navigable, and salt water streams of great value, which are not navigable. The application of the common law rule in this country would, therefore, result in nothing but absurd conclusions. The courts of this country have been discussing the problem for many years, and have come to different conclusions on the various branches or subdivisions of the question. On only one point is there an absolute agreement, viz: That the common law rule does not govern such questions in the United States, so

far as the right of the public to navigate the streams is concerned. That is, the courts hold uniformly that where the streams are sufficiently deep and wide to float boats, used in the interest of commerce and agriculture, the public has a right to use them as highways.

But, in whom is the title of the soil of the river's bed or in what rivers does the state hold the title to the bed, is differently decided in different courts.

The courts are unanimous in holding that ordinarily, where the tide ebbs and flows, the title to the bed of the stream is in the state.

Tied. R. P. 835.

But the state does not own the soil or bed of every creek in which the tide ebbs and flows. In order that the title to the soil of such creeks may be claimed by the state, the creeks *must* be practically navigable.

Rowe vs. Granit Bridge Corp. 21 Pick. 344.
Glover vs. Powell, 10 N. J. Eq. 211.
See State vs. Gilmanton, 14 N. H. 467.
Wilson vs. Forbes, 2 Dev. 30.
Am. River, etc., Co. vs. Andrews, 6 Ca. 1443.

But in respect to the title to the bed of fresh water navigable streams the courts are divided. A number of the courts have held that the fresh water streams are governed by the common law rule, in respect to the title to the soil under navigable streams, and that the title to the bed of the fresh-water streams is in the state.

Barney vs. Keokuk '94 U. S. 324.
McMauris vs. Carmichail, 3 Iowa; 1.
Shrunk vs. Schuylkill Co., 14 Serg. & R. 71.
Martin vs. Evansville, 23 Ind. 85.

The Supreme Court of Mississippi, in a very able and learned opinion, drew a distinction between public and navigable rivers.

It was there asserted that the principle, that the title to the soil of navigable rivers, i. e., rivers in which the tide ebbed and flowed, was in the State, was derived from international law. Tidal waters are the highways of nations, and very properly the title to the soil or beds of such streams was vested in the State. But where the navigable river is a fresh water

stream, although a sound policy would require a grant to the public of a right of way over it; there is no reason why a distinction should be made between them and non-navigable streams, in respect to the location of the title to the soil. It was, therefore held that the public have a right of way over fresh-water streams which can be navigated, but that the title to the bed is in the riparian owners, and the boundary line is its center line of the stream.

Steamboat Magnolia vs. Marshal, 39 Miss. 109.

The rule that the title to the beds of those rivers is in the riparian owners is supported by the following authorities:

Ryan vs. Brown, 18 Mich. 196.
People vs. Bratt, 17 Johns. 195.
O'Follow vs. Daggert, 4 Mo. 343.
Rhodes vs. 33 Ala. 578.
Canal App. vs. Wilkins, 4 Pick. 268.
Claremont vs. Carlton, 2 N. H. 369.
Blanchard vs. Porter, 11 Ohio, 139.
Berry vs. Snyder, 3 Bush. 266.
Ensminger vs. People, 47 Ill. 384.

The Supreme Court of the United States has held that the rivers, which from their location constitute the boundaries of States, and which are used, or may be adopted for use, in interstate and foreign commerce, are navigable streams of the United States.

The Danial Ball, 10 Wall. 557.
The Montello, 11 Wall. 411.

Let that be the controlling principle, and declare the title to the bed of such streams to be in the riparian States, in conformity with the decisions of the United States Supreme Court. Those streams might very properly be classed among the highway of nations, for the States in this connection are to be considered as separate and independent bodies politic. But the intra-territorial streams cannot be called international highways, and, therefore the title to the soil of such should be vested in the riparian owners, subject to the public easement of navigation.

Generally where land is bounded by a stream which is not navigable, the boundary line is the centre line of the stream, the *filum aquæ*; and the line changes its course with the natural and gradual change of the current.

Tied. R. P. 833.

But it does not always follow that the thread of the stream will be the boundary line, because the stream is referred

to in the deed. If the stream is mentioned as the boundary in general terms, or the land is described as "bounding on" or "running along" a river, the stream will be held to be the monument and the thread of the stream is the boundary line. And this is true although the deed describes the line on the stream as extending from one object to another, both of which are on the shore, as for example, "bounding on" the stream and "extending from." one tree on the bank to another. The termini of the boundary line are ascertained by drawing lines at right angles with the shore from these objects to the centre of the stream.

Lunt vs. Holland, 14 Mass. 150.
R. R. Co. vs. Schurmeir, 7 Wall. 286.
Cox vs. Fredly, 38 Pa. St. 129.
Commonwealth vs. Alger, 7 Cush. 97.
Brown vs. Chadbourn, 31 Me. 9.
Newton vs. Eddy, 23 Vt. 319.
McCullough vs. Aten, 2 Ohio 425.

But if the land is described as bounding "on the bank" or "shore" of the stream, then the low water mark on the banks will be the boundary. The particular reference to the bank excludes the stream.

Watson vs. Peters, 26 Mich. 516.
Child vs. Starr, 4 Hill. 369.
Daniels vs. Cheshire R. R. 20 N. H. 85.
Bradford vs. Cressy, 45 Me. 9.
Halsey vs. McCormick, 13 N. Y. 296.
Martin vs. Nance, 8 Head. 650.

Where the stream or its bank is the boundary line, it follows its meanderings, so that if the distance is given it is ascertained by reducing the irregular lines of the shore to a straight line.

Calk vs. Stribling, 1 Bibb. 122.
Hicks vs. Colman, 25 Cal. 122.
People vs. Henderson, 40 Cal. 32.

Where the land is bounded by a navigable stream strictly so called, i. e., where the tide ebbs and flows, the boundary line is the high-water mark on the shore.

Canal Comm. vs. The People, 5 Wend. 423.
Wheeler vs. Spinols, 54 N. Y. 377.
Niles vs. Patch, 13 Gray 254.
E. Haven vs. Hemingway, 7 Conn. 186.
Stewart vs. Fitch, 30 N. J. L. 20.

Where riparian estates are conveyed, the owner may reserve the land under water, but the general presumption is that the purchaser's title extends as far as the grantor owns, in both tidal and fresh waters.

The legal effect of the conveyance is determined by the terms employed, and cannot be controlled by parole testimony,

unless there is a latent ambiguity, or the description itself is rejected as false, or the identical boundary referred to in the conveyance is in dispute.

While the common law of England is supposed to govern us in laying a foundation for decisions in this matter, it must be remembered that the common law of England is not to be taken in all respects to be that of America.

Our ancestors brought with them its general principles and claimed it as their birthright, but they brought with them and adopted only that portion which was applicable to their situation.

Perrin vs. Lapper, 35 Mich. 292.

And since the common law has been modified in the different states so as to be applicable to their local situation, and it not being uniformly modified throughout the country, in determining the riparian rights, we must ascertain the law of the states within whose territory such lands are situated.

It is a well settled rule that the common law of England is in force in Michigan, and questions of property not clearly excepted from it must be determined by the common law, modified only by such circumstances as render it inapplicable to our local affairs, and especially in relation to the present subject matter.

The ordinance of 1787 (Art. 4.) for the government of the north-west territory, providing that "the navigable waters leading into the Mississippi and St. Lawrence rivers, and carrying places between the same, shall be common highways and for ever free, as well as to the inhabitants of said territory as to the citizens of the United States, and those of any other states that may be admitted into the confederacy without any tax, impost or duty, therefore, etc.," has been construed by the Supreme Court of the United States to vest in the several states the ownership of the bed of navigable waters.

R. R. Co. vs. Schurmeier, 7 Wall. 272.

The ownership of the soil under navigable water being in the state within whose territory such lands are situated, the decisions of the several state courts must be consulted to determine whether or not in any particular instance the riparian

owner on a navigable stream owns to the thread of the channel.

The question that now confronts us, is, what is the law of this state in respect to the title to the soil of the fresh water streams, ponds and lakes?

The right of riparian owners are nowhere mentioned in the ordinance of 1787, or in the acts admitting Michigan into the Union. The same being left to be settled according to the state law.

How. Stat. p. 29, Art. 4. Moore vs. Sanborn, 2 Mich. 519.
Burroughs vs. Whitwan, 50 Mich. 279. Webber vs. P. M. B. Co., 62 Mich. 627.
Benjamin vs. Manistee R. Imp. Co. 42 Mich. 628.

Where the land abuts and bounds upon a fresh water stream or river there is no question, and the law in such cases is perfectly plain and it is the settled law in Michigan that the title of the riparian owner extends to the middle line of the stream or inland lake,

Lorman vs. Benson, 8 Mich. 18.
Webber vs. Pere. M. B. Co., 62 Mich. 626
and cases cited on page 636.

and the current is not essential to the existence of riparian rights. They may exist in lakes or ponds where there is no current, and they may exist where the water is not capable of navigation.

Turner vs. Holland, 65 Mich. 453.

The rule has been one of property, in Michigan, and the United States Supreme Court has repeatedly held that it is the right of each state to determine the doctrine for itself.

Barney vs. Keokuk, 94 U. S. 324.
Hardin vs. Jordan, 140 U. S. 371.

If the channel of the river is divided equally by a middle ground or island, then the boundary line of each proprietor is a line running parallel with the course of the river and dividing the island into two equal parts. If the channel is divided unequally, then the smaller channel is ignored and the boundary line is the thread of the main channel.

Watson vs. Peters, 26 Mich. 518. Fletcher vs. Thouder, B. B. Co. 51 Mich. 277.
Crocker vs. Brogg, 10 Wend. 260. Trustee vs. Dickinson, 9 Cush. 548.

If such middle ground is owned by a third person, such person is a riparian owner as to each of the proprietors on the river, and the boundary line between his land and the land of each of

them is the thread of the channel between the middle ground and the main land.

People vs. Canal App. 13 Wend. 355.

Little difficulty is experienced in ascertaining the boundary line and riparian rights of the adjacent owners to narrow streams, and the rule recognized and approved in Michigan in determining boundary lines between adjoining riparian owners is that, "where the stream is straight, the water front will be the boundary by lines drawn at right angles with the thread of the stream, protracted until they reach the end of the shore line.

Where the stream curves the same principle applies, and the lines running from the shore would converge or separate, according as the land lay within or without the curve. In all the cases where the ownership of the submerged land or of alluvial increments, appurtenant to riparian ownership, has come in question, the only elements of which have ever been considered by the courts, have been the shore lines and the central line or thread of the stream, and the partition among adjoining owners has been made with reference to those, but never with any reference whatever to the direction of the boundaries or the extent of the domain on upland.

The aim in every instance has been to secure to each owner such share as was indicated by his shore line, and not by his lands back of it.

Lorman vs. Benson, 8 Mich. 18. Rice vs. Ruddiman, 10 Mich. 125.
Clark vs. Campau, et al., 19 Mich., 323, and cases cited on page 329.

In ascertaining the boundary lines and rights of riparian owners of lakes and ponds the difficulties one must contend with are more numerous, and relate mostly;

1st—To the impossibility of defining the boundaries where there is no *filum aquæ*;

2nd—The public characters of the waters which give the state much larger control than over strictly private waters, and

3rd—In fractional subdivisions of land.

In this country a distinction is made between public and private lakes, depending upon their size and value for purpose of navigation.

Rice vs. Ruddiman, 10 Mich. 125.
Verplank vs. Hall, 27 Mich. 79.
Lincoln vs. Davis, 53 Mich. 365.

The riparian rights on the Great Lakes, are, in theory, the same as upon navigable streams, and are not governed by any such proprietory division as high and low water mark. The submerged lands are appurtenant to the up lands so far as their limits can be reasonably identified; but in public waters the state law must determine how far right in such land can be exercised consistently with the easements of navigation.

The state can forbid any erection in navigable waters, and on navigable streams, and along the great lakes can fix the distance beyond which private erections cannot be maintained.

Lincoln vs. Davis, 53 Mich. 375.

Although by the common law under the grant of lands bounded on a lake or pond which is not tide-water, and is not navigable, the grantee takes to the center of the lake or pond, ratably with other riparian proprietors, if there be such.

Hardin vs. Jordan, 140 U. S. 371.

Grants by the United States of its public lands bounded on streams and other waters, made without reservation or restriction, are to be construed as to their effect, according to the law of the state in which the lands lie, and as heretofore stated, it depends upon the law of each state to what extent the prerogative of the state to land under water shall extend.

Hardin vs. Jordan, *supra.*

The question often arises as to the title in reference to the lake and the bed of the lake in front of the land actually described in the grant.

It has been the practice of the government from its origin in disposing of public lands, to measure the price to be paid for them by the quantity of upland granted, no charge being made for the lands under the bed of the stream or the body of water.

The meander lines along or near the margin of such waters are run for the purpose of ascertaining the exact quantity of upland to be charged for, and not for the purpose of limiting the title of the grantee to such meander line.

It has frequently been held by the courts of this state, and the United States Supreme Court, that such meander lines are

not intended for the purpose of bounding and abutting the lands granted upon the waters whose margins are thus meandered; and that the *waters themselves* constitute the real boundary and that the private ownership of lands bounded on navigable water is not restricted to the meander line.

R. R. Co. vs. Schurmeyer, 7 Wall. 272.
Pere Mar. B. Co. vs. Adams, 44 Mich. 43.
Jefferis vs. E. Omaha L. Co., 134 U. S. 178.
Clute vs. Fisher, 65 Mich. 48.

In Clute vs. Fisher, the court held that, "the owner of a fractional subdivision of land, made so by an inland lake, owns the soil under the water of said lake which would be included within the subdivision if its lines were *fully* extended, and can maintain trespass against any one who cuts and removes the ice formed over *such* soil without his consent."

This principle was based upon the case of Palmer vs. Dodd, 64 Mich. 475; Wilson vs. Hoffman, 54 Mich. 246, and Keyser vs. Sutherland, 59 Mich. 455, which cases were based upon Brown's Lessee vs. Clements, 3 How. 650, in which cases the court held that, "No grantee by a patent, granting a legal subdivision of land, can derive title to land upon another legal subdivision."

The case of Brown's Lessee vs. Clements, upon which the Michigan decisions were based was overruled in Gazzan vs. Lessee of Philip, 20 How. 372.

In Grand Rapids Ice & Coal Co. vs. South G. R. I. & C. Co., 60 N. W. 681, the inconsistency of the rule set forth in Clute vs. Fisher with the rule repeatedly laid down in this state, "that the shore proprietor owns to the center of the stream," is set forth.

The court says: "It is also inconsistent with the rule laid down in Clark vs. Campau, 19 Mich. 328, and Bay City Gas Light Co. vs. Industrial Works, 28 Mich. 182, that side lines are to be governed by the course of the stream and the submerged land bounded by lines drawn at right angles with the central thread, rather than at right angles with the shore at the point of departure." Again the rule that a conveyance of a fractional subdivision actually conveys the entire subdivision

is inconsistent with the rule laid down in Boon Co. vs. Whitney, 26 Mich. 42; Dart vs. Barber, 32 Mich. 271; Jones vs. Pashby, 62 Mich. 614; Hartford Iron Min. Co. vs. Camboia Min. Co., 80 Mich. 491.

In each of these cases part of a parcel of land having a water frontage was conveyed, described it as one-half of the lot or parcel; and it was insisted that the conveyance was of one-half of the water frontage, but the court held that the words "half of the lot" meant "half of the quantity of upland." A correct result was given in the Clute case, but the reasons given are without support.

The reason the result is correct in the Clute case is because the meander lines were almost wholly and the water lines were wholly within the subdivision owned by Clute. And that "no claim was made that an apportionment would give the right to cut the ice to some one other than Clute, but the sole contention was that the title to the bed of all the lands within the meandered lines was in the state. And it was that question the court was dealing with."

Many of the decisions relating to, and the doctrine of riparian rights, are quite fully discussed in Grand R. I. & C. Co. vs. S. G. R. I & C. Co., by the learned Chief Justice McGrath, and on page 684 the court says, that: "The shore proprietor takes by virtue of shore ownership. His interest in the bed of the stream he acquires as appurtenant to the grant, and the extent of that interest depends upon his frontage, and the form, length and breadth of the body of water upon which he abuts. That the lake may be of such form as to render the designation in it of the boundaries of the several riparian owners somewhat difficult, is not an objection to the application of the rule."

In Lincoln vs. Davis, *supra*, Mr. Justice Campbell, in laying down the rule of lines of ownership on lakes, says: "On lakes all lines from the shore tend to converge in some central part of the lake; and while irregularity of shape prevents drawing them to a common center, they must all, if protracted, cross each other in a perplexing way. The rule adopted in such waters where the whole surface could be appropriated,

has always been to divide the water area in proportion to the shore frontage, and never to attempt any division by lines run from the shore, except over such parts of the lakes as are substantially adjacent to the shore. In some cases by a fair partition, a shore owner by his extent of shore line, may obtain a share beyond the center. But it seems impossible, if the whole water is to be regarded as divided up, to reach a division without some proceedings in the nature of a partition, which will fix the various possessions."

The G. R. I. & C. Co. vs. S. G. R. I. & C. Co., where the controversy was over the right to cut ice in Reed's lake, plaintiff insisting upon ownership of the bed of the lake within the lines of the fractional subdivision extended, and the defendant insisting upon a division of the center line proportionate to the shore line, so as to give to each riparian owner an equitable share, the court say, that "where a navigable lake of such size that entire sectional subdivisions are included therein, the owner of a fractional subdivision of a section, meandered by the United States survey along the margin of the lake, does not own all the lake lying within the extended lines of his subdivision," and is governed by the rule laid down in Johnson vs. Lee, 77 Mich. 35, in which Mr. Justice Campbell on page 40, says: "It appears clearly enough in the present case that while there is a considerable frontage facing north-west and south-east, the lake being longest in that direction, there must also be large frontages, which look up and down the lake perpendicularly, or nearly so, to any line across from bank to bank, and most places along the shores. If this body of water were not navigable, and if all its waters could in any way be apportioned among the riparian proprietors for any lawful purpose, it is evident that it could not be done by any reference to any *filum aquæ* or middle thread, but must be done by some rule of proportion, which probably could only be got at by some partition proceedings, inasmuch as such waters are common for all ordinary uses, unless it may have been placed in a different position by the public surveys, as has been done in many instances of small so-called 'lakes' not navigable."

In B. & D. Lumber Co. vs. Peters, 87 Mich. 498, where the

complainant and defendants were adjoining owners of parcels of land bordering upon the waters of Green Bay, which is a part of the waters of lake Michigan, and navigable for all classes of vessels, both parties owned and operated saw mills, and constructed wharves to the deep water of the bay, upon which to pile and from which to ship their lumber. The question in dispute related to the subdivision line of their respective holdings under the waters of the bay, and in deciding the case, the court say (on p. 506-7); "Upon consideration of the authorities cited, we think the rule adopted in Massachusetts will, in cases like this, secure a nearer measure of justice than those adopted by the courts of any other state. We cannot deal with Green Bay as we could with a river in this state, where the lines are to be drawn at right angles to the thread of the stream. The rule laid down for the boundaries of owners of land bordering upon the ocean and great inland seas are more proper for the disposition of the case before us. The rule defined in Massachusetts is:

1st—To measure the whole extent of the ancient bank or line of cove or bay, and compute how many rods, yards, or feet each riparian owner upon such line has.

2nd—To divide the newly formed line into as many equal portions as those contained in the shore line, and then draw straight lines from the point at which the proprietors respectively bounded on the old to the points there determined as the points of division on the newly formed line."

It is freely admitted that this rule may require modification under particular circumstances in order to secure equal justice, and that, in ascertaining the shore line or margin of the water, a general line ought to be taken, and not the actual length of the line on the margin, if it happens to be elongated by deep indentations or sharp projections, so that the line shall embrace the general available line of the shore. This is exactly what the meanders run by the United States government do.

The lines are run straight, disregarding indentations and projections which are not available for any general useful purpose.

"The object to be kept in view in cases of this kind is to secure to each proprietor access to navigable water and an equal share of the dockage line of navigable water in proportion to his share on the original shore line." In Hardin vs. Jordan, *supra*, where the subject of riparian rights has been very ably and exhaustively treated, and where the Roman, English and American authorities have been very carefully considered, and to which I invite your attention, the court on page 402 say: "If there shall arise any question between the plaintiff and other riparian owners of land situated on the margin of the lake, as to the convergence of the side lines of the plaintiff's land in the lake, it can be disposed of by the parties themselves by a resort to equity or to such other form of proceedings as may be proper."

I have not cited any Massachusetts or Maine decisions in support of the position above taken in reference to the title to the soil of lakes, for the reason that in those states they are governed by a Massachusetts ordinance passed in 1647, which makes all lakes of more than 10 acres extent public, and therefore deny that ownership of such lakes extend to the center.

The decisions of the courts in other states, which deny private ownership of the bed of small lakes, are mostly based on the Massachusetts and Maine decisions and have cited them in support of their position, perhaps not realizing or recognizing the fact that they are governed by the Massachusetts ordinance.

Since it is the well settled rule, that, at common law the riparian owner takes to the center of the stream, or other waters that are non-tidal, and that the meandered lines are not the boundary lines, it is held that, when the United States has disposed of the land bordering on the meandered lakes by patent, without reservation, or restriction it has nothing left to convey, and any patent thereafter conveyed for land forming the bed of the lake, or former bed, is void and inoperative.

Lamphrey vs. State, 18 L. A. R. (Minn.) 670.
Hardin vs. Jordan, *supra*.

However, it has never been held that the lands under water in front of such grants, are reserved to the United States,

or that they can be afterwards granted out to other persons, to the injury of the original grantors. To attempt to make such grants is calculated to render titles uncertain, and to derogate from the value of natural boundaries, like streams and bodies of water, and it is well settled that the grantee takes the fee with all the riparian rights incident to the ownership of riparian land, including the right of accretions and relictions.

With regard to grants of the government for lands bordering on tide water, the court in Hardin vs. Jordan, *supra*, on page 381, say: "It has been distinctly settled that they only extend to high water mark, that the title to the shore and lands under water in front of lands so granted enures to the state within which they are situated, if a State has been organized and established there."

Such title to the shore and lands under water is regarded as incidental to the sovereignty of the State—a portion of the royalties belonging thereto and held in trust for the public purposes of navigation and fishery—and cannot be retained or granted out to individuals by the United States.

Pollard vs. Hagen, 3 How. 212.
Gootitle vs. Kibbe, 9 How. 471.
Webber vs. Harbor Com. 18 Wall 57.

Generally speaking the true meander line of a navigable stream or lake is the point to which the water usually rises in ordinary seasons of high water. In a question of boundary the position of that line is a question of fact for the jury; and it controls, although the meander line of the survey is found not to be coincident therewith.

Gould on Waters, Sec. 76.

In fixing private right or lines, "a surveyor cannot be allowed under any circumstances, to fix private rights or lines by any theory of his own. Before a surveyor's evidence can be received at all, it must be connected with the starting points and other places or lines called for by the grants under which the parties claim. His duty is neither more nor less than to measure geometrically in accordance with those data, and his science goes no further. It is not his business to decide questions of law, or to pass upon facts that belong to the tribunal

dealing with the decision of fact. His testimony as a man of science, is never receivable except in connection with the data from which he surveys, and if he runs lines they are of no value unless the data are established from which they are run, and those must be destinctly proven, or there is nothing to enable any one to judge what is the proper result."

Jones vs. Lee, 77 Mich. 43.

In conclusion, gentlemen, I desire to thank you for your kind attention, and while I have not treated this subject as fully as one might, I trust that what I have stated will be of benefit to you. HUGO P. GEISLER.

Saginaw, Mich., Jan. 7th, 1896.

Question submitted by Mr. Courtright.

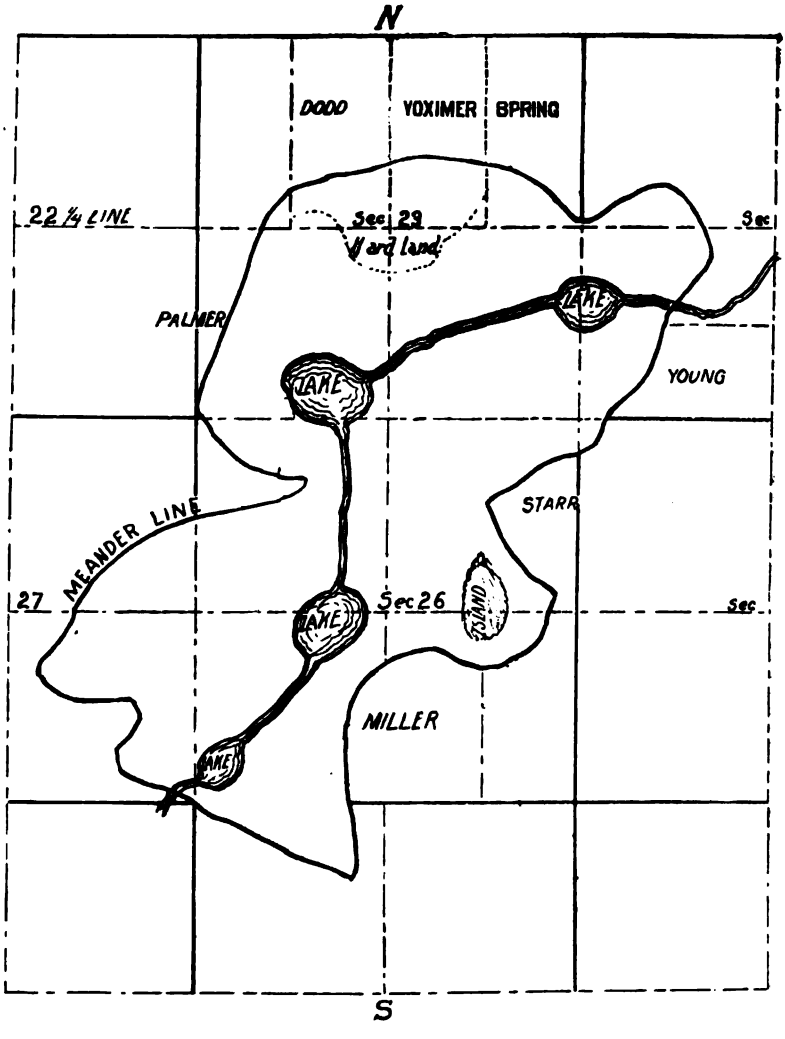
Mr. Hodgman.—Over in the country spoken of by Mr. Courtright, there is a tract of country that is represented in the field notes and plat of the United States survey, as being a lake, and it covers a considerable part of several sections. But in fact, instead of being one large lake, covering a considerable tract of territory, there were three little lakes there, connected with a stream (illustrated by diagram).

Some years ago, a man by the name of Palmer, owned the S. E. ¼ of Section 22, and land adjoining it in Section 23. Part of what is represented as lake in the S. W. ¼ of Section 23, was really hard timber land. Mr. Dodd, who owned the E. Fractional ½ of N. W. ¼ of Section 23, undertook to take the timber and Mr. Palmer claimed it, and they had a law-suit and Mr. Palmer held it. Now the question comes up in regard to the S. E. ¼ of Section 23. The United States have never given any title to it directly, supposing it was all water; they never have given any patent to the S. E. ¼ of Section 23. Now who owns it? Do the parties, adjoining the lake on each side, own it, or if not, who does?

Mr. Rogers.—What are those squares? (referring to diagram). Do they represent quarter sections?

A. Yes sir.

Q. But the hard land that is represented in the Government Survey, is that known as a fractional quarter?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DODD
YOXIMER
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22¼ LINE
Sec 29
Sec
Marsh land
PALMER
LAKE
LAKE
YOUNG
STARR
MEANDER LINE
27
Sec 26
Sec
ISLAND
LAKE
MILLER
LAKE
S

A. I don't know about that. I presume it was sold as fractional quarter sections.

Q. The whole line of the larger circle there is a meander line?

A. Yes sir. The S. E. quarter of 23 is not in the market. The question is, who owns it?

Prof. Geisler. The Government only uses a meander line for the purpose of measuring the upland. The rule is that they charge for only the hard land, but under the ordinance for the regulation of the N. W. Territory the Courts have construed repeatedly that the United States cedes the land under water to the State. Now the question arises, does the State cede the right to the title of the land under the water to the shore owner?

We have adopted the common law in this State, which makes all waters that are not tide waters, non-navigable, and the title to the thread of that water belongs to the riparian owner. To apply that here, we have modified the common law rule, as applicable to our local affairs. I would then say that we ignore the meander line, and if this part has never been conveyed by patent of the United States, the riparian owner would go beyond the meander line and take the soil under the water and have title to it.

Now the question is to divide it by boundary lines. It covers more than one section and you could not apply to it any of the State rules. You would have to have a partition suit and if the adjoining owners could not agree among themselves, you would have to have it settled by a Court of Equity.

Mr. Courtright.—The Supreme Court held that Dodd could not cross that quarter line.

Mr. Geisler.—That position is emphatically wrong. The decision of Dodd vs. Palmer was based upon two other Michigan cases, and if I remember aright they were based upon some Massachusetts doctrine, which was governed by an ordinance which was only applicable to the New England States, and it has misled a great many states in this country, and I

think if that Dodd case was ever brought up again, that the Court would make another ruling.

Q. Supposing Palmer's deed covers the S. W. Fractional quarter, and Dodd's deed covers the N. W. quarter, why should Dodd hold on the S. W. quarter?

Mr. Geisler.—Now you say the Palmer deed calls for the S. W. quarter of 23. The entire quarter section?

Mr. Courtright.—Palmer's deed calls for the S. W. fractional quarter of 23. Dodd's deed for the East half of the N. W. fractional quarter. Why should Dodd be allowed to hold on land that Palmer's deed covers?

Mr. Geisler.—For the reason that when this land was meandered by the United States, this was water– considered so by the Government—the Government was not selling the water, but simply the land which was really in existence and they were charging for that particular part. He buys that particular land, subject to all its riparian rights, in conformity with any other riparian owners there, and the rule would then be applied that they would have to divide their land according to whatever would be just.

Mr. Courtright.—That would be, with the understanding that the Dodd and Palmer case was decided wrongly.

Mr. Geisler.—It was wrong, unless there was an irregularity in the survey, and a positive showing that the United States corrected the meander line before they deeded the property. Now the State claims to have no title to the S. E. quarter of 23. The title should be divided according to the rules laid down, by actual measurements, and if they cannot be applied, you would have to have a partition suit, and that would be decided according to the frontage of the individuals.

Q. What would be the direction of Dodd's west line, after it crosses the quarter line? Would it be produced, or in a different direction?

Mr. Geisler.—Necessarily a different direction, owing to the surrounding lines. I do not think it would be a straight line. Of course that would have to be figured out, according to the frontage of each individual.

Q. In your opinion, would it be likely to apportion that

area within the meander line in the same ratio as they hold lineal feet in the meandered area?

Mr. Geisler.—I think that would be followed in a partition suit, but you could not follow it by any set rules of survey.

The President, Mr. Wells.—Some time ago, I read of a decision in a case like this: A man buys this fractional piece of land and the water rights, and the decision was that he could only claim within the boundary lines of that fraction.

Mr. Geisler.—That has been gone back on.

Mr. Hodgman.—It may not perhaps be out of the way, at this point, since President Wells has raised the question, to say that the Michigan Engineering Society had something to do with bringing about the reversal of the Supreme Court decision, Clute against Fisher, in which the Supreme Court decided that the parties held out to where their boundary lines would have been if there had been no water there.

At a session of our Society, held at Kalamazoo in 1887, that decision, as well as the Wilson-Hoffman case, was criticised by our Society.

These decisions, as well as the Palmer vs. Dodd case, brought up by Mr. Courtright in his question, were all based on a decision of the Supreme Court of the United States in the case of Brown's lessees vs. Clements, 3rd Howard, 650. This was a case brought up from Mobile, Alabama, and decided in 1845, and it was held that the party holding the patent to the S. W. ¼ of Sec. 22, containing 92.67 A. was entitled to an entire quarter section, although the official plat showed it to be fractional and another party had the patent to the S. E. subdivision of it. In 1858 the same tract of land came into controversy again, and it was brought the second time before the Supreme Court of the United States in Gazzam vs. Phillips, lessee. This time the court reversed the decision in the Brown vs. Clements case, saying that it was contrary to their own previous decisions and to the uniform practice of the Land Department of the United States for thirty-eight years, and that less harm would result from reversing the decision than from following it.

The Michigan Engineering Society called the attention of the Supreme Court of Michigan to these facts, and that body

immediately, of its own motion, recalled the case of Wilson vs. Hoffman, and reversed their decision. As a reversal of the Clute vs. Fisher case would have made no practical difference to the parties concerned, it was not recalled, but Judge Sherwood told me at the time that the decision in that case would not be followed by the court in its future rulings, and it has not, so far. In the recent case at Reeds Lake, near Grand Rapids, the court went squarely back on it.

Mr. Geisler.– The reason, I should say, that a riparian owner would continue beyond the meander line is, in all States in which the common rule is applied, that after the United States has once patented the land adjoining the water it has nothing more to patent, for the reason that it never reserves anything under the water, because if it should do so, it would make the titles unsafe and an adjoining owner would not know what his rights were.

The theory to be guided by, is to ascertain in the first place, whether you are regulated by any statute other than the common law, and if you are regulated by the Common Law, you will be safe in saying that in all waters, not tide waters, whether navigable or not, the owner owns to the the thread of the stream, for this point is well settled.

In one English case, the question came up a few years ago regarding a lake of some 13,000 acres. The contention was that the rule of the Common Law was that all rivers in which the tide ebbed and flowed were navigable, and others, non-navigable. They tried to take the position that that did not include lakes, but the highest courts in England have taken the position strongly, that the Crown of England does not own any soil under the water in lakes that were not "deep waters."

The rules of Common Law apply not only to rivers, but to lakes of all descriptions, and on that position, the law is applied to the Great Lakes; the only difference is that the public character of the water gives the state more control than over strictly private waters.

Mr. Courtright.—The idea, then, advanced by the Supreme Court, that possession gives title; these people have had possession of that for several years,—

Mr. Geisler (interrupting).—You mean by Adverse Possession. There is a rule that you cannot get adverse possession against the United States. You can get adverse possession against a private individual, if he has once bought the land, but not against the United States if the land has never been sold.

Mr. Hodgman.—I don't fully grasp the situation there. Of course if the Common Law rule holds good, the United States has parted with its title. Is it the riparian owners that have possession of the S. E. ¼ of 23, or someone else?

Mr. Courtright.—It is the riparian owners.

Mr. Hodgman—If the riparian owners have possession, they can keep it all right. The question is, how much they will get.

Mr. Courtright.—How will they divide it among themselves under the Common Law rule?

Mr. Geisler.—If you cannot apply any of the well-settled rules of survey, by running the lines perpendicular to the shore, you will have to have a partition suit and divide the area of the water in proportion to the frontage you have.

Now the case referring to Green Bay, I should say would be applicable to that. I have forgotten the title of the case, but it is cited in my paper.

Mr. Rogers.—I would like to ask Mr. Geisler a question. Supposing the Government owns a water route on a river like Saginaw river, and dock lines have been established along the river and approved by the United States Government, and supposing an individual wishes to build or put up a substantial building, clear out to the dock line; could anybody stop him?

Mr. Geisler.—To what extent is the river navigable?

Mr. Rogers.—It has been dredged out by the Government and is navigable for quite large vessels. Of course no person can build an inch beyond the dock line, but suppose he is willing to dispense with the dock, and use the land for a warehouse; could he do it?

Mr. Geisler.—Who established the line?

Mr. Rogers. The United States Government; it was approved by the Secretary of War.

Mr. Geisler.--Yes, he can go to the last inch. The Government does not recognize dock lines established by cities, but where it establishes them itself, you can go to the last inch. Of course, many times, things of that nature would be governed by circumstances. While a rule strictly laid down might work all right in one case it might create injustice in another. A person would have to use his best judgment and common sense to know how far to extend the lines.

Mr. Skeels.--I am a little interested in another question. For instance. The City of Grand Rapids has bought Island No. 1 for a city market. A spot near the upper end of that island has been used as a dumping ground by the city. Now the material from this dumping ground has washed down to the head of that island, and in reality the area of that island is much greater than what was returned by the Government surveyor; would that properly be considered accretion to that island or must the City Government proceed on the ground and re-meander the island and establish, as far as possible, the old meander line and not go beyond it, or can they include all that part gained by the accretion?

Mr. Hodgman.—Can the city go on and make its own accretions or not?

Mr. Appleton.—That is done in Grand Rapids. If a man wants a piece of land along the river, he fills it up and occupies the bank.

Mr. Geisler.—You say this is an island in the centre of a stream?

Mr. Skeels.—It is an island in Grand River. The channel on the east side of the island proper has been dredged and used as a basin for some boats. They come up the river and turn in there and tie there, and it has been filled in from the mainland, across what was the upper part of this island, and made a highway from the main land around on to the head of the island, but it has been established I think, by decision of our courts, that that channel was there, and it has been located, but as it is now, it is connected with the main land, the island is, but although the island lies east of the body of the river, and the river is now on the west side of the island, yet at the time

it was meandered, there was a large channel on both sides; steamboats went up either side of the island.

Mr. Appleton.—Better pitch into the City of Grand Rapids for obstructing the river.

Mr. Geisler.—Has there been any dock lines established on the island?

Mr. Skeels.—I think so. We have done everything that anyone else has.

Mr. Geisler.—In answer to that question. The rule is that you are entitled only to those accretions that come gradually, but if that is a slow working accretion, helped along, perhaps, by the washing of the waters, it is hard to tell what position the court would take. I think, applying the rule strictly, they would not be entitled to any accretions, but what position the court would take in a case of that kind, it is a difficult matter to tell. I think you will find a great many authorities that would hold both ways, but there would be no question about it that you would not be entitled to the accretion if you dumped it all there in a week or a year, but if it was also the washings of the shore and the alluvial lands, it would raise a different question. These things would have to be taken into consideration and also the exact location.

Mr. Skeels.—There was quite an accretion there before the dump proper, got to the island.

Mr. Geisler.—It might be situated in such a way that the accretion would naturally form. This might cut a very important figure in deciding the case.

Mr. Skeels.—What I wanted to draw out was, where would the island leave off and the artificial land begin? The Common Council has authorized the City Engineer—well, it is sort of a double order or has two bearings. One was to find where the old meander line ran and the other is to determine the lines of the property they have purchased.

A. They can't do it.

Mr. Skeels.—The point to meander from is unfindable; we can guess at it as we do at many other things, but it is impossible from any data we have left to locate the point from which the meander commenced.

A. Then the best thing to do is to claim all you can, and let the other fellow tell you how much you can't have.

A Voice.—The best way is to let the man that they bought of give the lines.

Mr. Hodgman.—Get the lines as near right as you can and let someone prove them wrong if they can.

Mr. June.—That is a question which is referred largely to the judgment of the surveyor; Judge Cooley calls it the judicial functions of the surveyor, and if it depends on his judgment, what should his judgment be based upon, the reasons, or should he foresee the action of the court? His judgment is all right if the court don't dispute it.

Mr. Hodgman.—It is utterly impossible to foresee what the court will do.

M. Geisler.—The judgment should be based upon equity and sound common sense.

Mr. June.—But that common sense has got to be in line with the courts.

Mr. Wells.—My idea is to go ahead and make tracks for the courts to follow. I have been interested though, in some cases where we tried to make some rules for the court to follow, and they jumped clear over the fence.

Mr. Appleton.—I suppose all there is for a surveyor to do now is to find the old line, and if he can't do that, find it as near as he can.

Mr. Hodgman.—There is one thing about it. Not more than one case out of a hundred goes beyond the surveyor's decison. If the surveyor goes before his patrons and does his work thoroughly and honestly, and is willing to tell his reasons why, and they are plain and substantial justice, in ninety-nine cases out of a hundred his judgment will be accepted right there.

Mr. Geisler.—I can say this; if there is any trickery by a surveyor, the chances are it will be found out.

ELECTROLYSIS.

THOS. P. WHITTIER.

The profession of electrical engineering can be fitly compared with that of medicine. There is some fundamental knowledge in both, but it is largely empirical.

They remind me of the old gentleman, who, being very sick, had a consultation of physicians. Thinking they had not told him his real condition, he asked his old colored servant what he had heard them say. The reply was, that after considerable talk, they said, "the autopsy will tell." So it is with elecrical engineering; the autopsy tells.

On some points there is ignorance, real or assumed, for which there is no excuse; notably the damage to water, gas and sewer piping. This brings up the question: "Can anyone rightfully appropriate the property of others to his own use, to the detriment of the owner, without recourse, because the manner of the appropriation is not generally known?"

The business men of this city, as in all cities in which the earth is used as a return conductor for heavy electrical currents, have suffered materially from the destruction of their piping, and the city, as a whole, from the destruction of its water piping, saying nothing of the interruptions to private interests by these appropriations of the metal that they have placed in the ground.

It is a well known fact that electricity will, like other demonstrations of force, go where it can go the easiest, and that it is an utter impossibility to confine the current to one conductor when there is another open to it that will lessen the total resistance in the circuit, and any conductor offering a second path will reduce the total resistance, no matter what the second path's resistance may be.

One of the hobbies that electrical engineers have ridden, is, the increasing of the cross-section of the rail to carry back

the current in street railway service to the generating station. There was a period in electrical investigation in which they figured the earth as naught, as resistance. I remember some years ago, being with experts at Chicago, when this subject came up. At that period it was generally understood the earth was common property, and knew no metes and bounds as regards its use for private or corporative companies. I suggested the idea to them that I had been at work measuring earth resistance, when they pooh-hooed the idea and flashed their fundamental law upon me. I asked them if they remembered the experiment of the Western Union Company, in one of which was a large bicromate battery set up for the purpose of breaking a hole for the return current between Chicago and St. Paul. They said they remembered the fact, because it was quite a question whether there should not be another conductor sent to St. Paul to take back return current, and it would cost a good deal of money. I then asked them what was the necessity of so much potential or pressure, if it was not to overcome the resistance of the earth, when one of them, who had been long in telegraphic employ, agreeing, cited that they had brought one of the cables of the Atlantic coast out upon a ledge of slate, and that to get a good return, had to anchor an electrode some distance from the shore to establish the practical use of the earth return. In bringing up this question of earth resistance, we consider the earth not only as a conductor, but as a network of conductors; or in a comparative sense, using the human body as an example, with its blood circulative system already properly proportioned for the maintaining of life, and utilizing these venal and arterial channels for entirely outside work. Now, should we break down the walls of these channels, causing a lesion, this lesion would cost the life of the person or great sickness: and should this lesion take place in the brain, paralysis or apoplexy would ensue. We have not yet had any such extreme case, but should this use of our water system continue, and a fire such as we have had, occur, and such demands on our water system result, as we have had, paralysis would be a mild method of expressing the disaster caused by this appropriation by owners of heavy currents.

In street railway construction of the present day, we find an overhead conductor used to carry the current from the power station to the cars, thence back to the dynamo though the rails. In every electric system of this character there must be a complete circuit, or in other words, if you carry a given amount of current out over a conductor, there must be the same amount returning to the opposite pole of the source of current; hence there must be as much return to the dynamo through the rails as is taken out through the overhead trolley wire. As the rail is used as a conductor while imbedded in the earth, which is also a conductor, we must consider which is to do the greater part of the work of returning the current. By proper bonding of the rails, and by a system of return wires connected to the rails at short intervals, the resistance of the rails and return system is brought within reasonable bounds, and so long as the connections are perfect between wires and rails, the flow of current through the earth is comparatively small, but the continual pounding of the cars over the rail ends tend to loosen the joints, and the formation of an oxide of the metal very materially increases the resistance, while the earth resistance remains the same (subject to the variations caused by moisture). Thus the tendency of the current to take the path of least resistance or distribute itself among the conductors in the earth, shows that it may follow a system of piping to a point near the power house where the greatest quantity of electrolysis of metal is going on, because all the current must come there by whatever means it takes to return, and so our piping first gives out in that vicinity, though it is going on at all other points more or less, in proportion to the use of current. Direct current of any sort will cause the same result to metals imbedded in the earth. Supposing an electric light current becomes grounded in two places. There is a flow of electricity between these two points which tends to decompose conductors; as may be inferred, the street car rail is undergoing decomposition, but very slowly, as the current is not leaving at any one point, but evenly distributed throughout the entire length of both rails.

In crossing rivers on a drawbridge, the common practice is

to use an uninsulated wire for the return, laid on the river bottom. This gives a second path of comparatively low resistance, as the body of water is enormous as compared with the wire, which is usually of copper. Were the cross-section of the two conductors the same, there would practically no current flow through the water, as the specific resistance of copper is but .000,001,504 legal ohmes, as compared to 9,320 legal ohmes. The first measurements by Dr. Matthiessen, the second by Pouillet. The current would divide in this ratio (inversely), provided there was no work to be done in the decomposing of the water which would tend to raise the apparent resistance of that path, but when the relative size of the two conductors is considered, it will be seen that the only resistance of the water to be considered is that of contact with the wire.

Poor insulation of wires carrying heavy direct currents gives rise to leakage through the earth, but as a rule this is very slight, as any very heavy ground (as it is known in practice,) would or should be known by the dynamo tender shortly after its appearance. However, faults of this character may and do exist, to a small extent, without the knowledge of the attendant, and while the electrolysis from such source is small, it is present never the less, and if continued over an extended period of time, will be felt.

Is our water supply the only source of anxiety we may have? What if this degeneration of iron piping should eat through a large gas main and the pressure upon the pipe force a hole into the sewer and a mixture of the gas with air in the sewer be ignited, by a man attending to his duties of cleaning a catch basin, with a lamp or a lighted pipe? Are we not living over the crater of a volcano that is liable to carry us to the destruction of human life, which is far more dear than the destruction of property?

Every engineer knows the result on conductors of crystalization caused by carrying direct current. This applies to our bridges, which are in several instances upon this river being used by a return current which may give us an Astabula disaster.

Do the electrical engineers who advocate the bonding of rail, appreciate the fact that the use of a bond other than of the same material from which the rail is made, is simply increasing their resistance, for local action between different metals decomposes one and also creates secondary or counter electro motive force, and while as an instance, men have been criticized for using iron wire as an excuse to comply with the laws created by city governments (and they were laid, not from the knowledge that they were better had they been larger), but because they were cheaper.

Taking it up as a question of secondary action or electrolysis of metal, they are forming oxides at the points where the current makes these jumps from rail to bond, and from bond to rail, all of which set up the opposing force of increased resistance, and necessitates an extra creation of horse power to overcome such resistance.

The doctrine of conservation of energy teaches us that no work can be performed without an expenditure of energy, hence it will be seen that in an electric circuit where the current is running cars or lights, in getting back to the dynamo is decomposing metal; the person or corporation supplying this current is paying for the electrolysis as well as for the operation of the motors or lights. The salt used for the reduction of snow and ice resistance on tracks and the surface grading of roads and pavements increases the ease with which the current is carried to our water, gas and sewer mains, and therefore should be discouraged as much as possible.

In electrical construction or engineering of any sort, the period is here, when men constructing work will necessarily have to insulate from outside influence, all metal placed in the ground, or advocate the use by corporations of their own conductors for return of current.

ELECTRIC STREET RAILWAY CONSTRUCTION FOR CITIES.

R. W. ROBERTS, CITY ENGINEER, OF SAGINAW, MICH.

The question of a permanent street car track is today annoying municipal public works officers and street railway managers, to the extent that it is requiring the exclusive attention and service of engineers. Prior to the early part of the year 1886, the surface street car roads of our cities were generally operated by animal power, some of the larger cities where cables or "Grip" cars were in use being exceptions; the service was conducted in small, light cars with a maximum weight when loaded of four tons, and an average of not to exceed two tons on a 6-foot wheel base. With these light rolling loads little attention and skill was required in constructing the road bed and track other than the service of an experienced trackman to properly line and surface the rails of the track, and such tracks would stand the service for years in an improved street, with little if any repairs and without damage to the street surface and subterranean property.

In February 1886, F. J. Sprague constructed and equipped the first electric trolley surface street railway in Richmond, Va., that was exclusively and successfully operated by electric motive power; this was the beginning of a new era in street railway service, and since that time over 4,500 miles of surface street railways have been equipped with electric motive power over which are operated about 7,000 electric cars. Until within the past three years electric surface street railways were somewhat experimental, but since that time the requisites for a successful electric street railway are practically agreed upon, while there are changes in the minute details at all times, the salient points are fixed. A large per cent. of the electric street railways of today are old horse car roads which adopted the new mode of propulsion. The electric equipment of a street car system,

cars, power station, trolley wires and poles were very expensive and as a general thing the capital of the promoters was all consumed before track construction commenced, resulting in operating the old horse car tracks which caused many disappointments; everything was too weak, motors had to be made stronger and heavier, more people were carried per car, the speed was greater, the stops and starts were quicker, and so it went on with every detail of construction until today rapid transit requirements in cities, for strength and durability of roadbed and rolling stock, are fully equal to steam railroad requirements, and in some respects exceed them. The ordinary electric motor street car, loaded, weighs 16 tons, and the most approved cars now in use on the rapid transit lines connecting suburban towns with the larger cities, weigh with load, 25 to 30 tons.

The track laid to carry these loads and keep its surface and alignment and be so rigid as not to vibrate sufficient to loosen the pavement along the rails, and that will continue so without repair for eight or ten years, is the track now desired both by street railway managers and municipal authorities. When the engineer is seeking information as to street railway track construction he is naturally directed to the experienced officers of our steam roads, but the conditions of maintenance are so different that the street railway must have a different construction A steam railroad track is under constant supervision of section men every day in the year, there is nothing in the way of tamping up a low joint or surfacing and lining the track every time, the track would be improved thereby. Steam railroad roadbeds are elevated either on embankments or in excavation above the surface water level so that the water drains off rapidly, the base of rail can be proportional to the heighth. The street railway cannot be repaired without first removing the surface of the pavement and foundation; and this cannot be done without interruption to travel, expense and damage to the street surface; the grade cannot be elevated above the surface water line, as it must be to the fixed street grade which should be below the grade of the abutting property. The rails cannot be the best proportioned and most

economical but must be suited to the kind of street surface or travel upon the street; the track must be on a rugged foundation with the least possible vibration.

There is a good deal of contention as to the best kind of rail head for street use. Three years ago the writer visited several of the progressive cities, seeking information from which to decide as to the best street rail, and found a variety of rail sections in nearly every city visited, so there seemed to be no unanimity of practice as to the kind of rail in use. Many of the older cities still adhere to the tram top girder rail, but the rail section being most laid at that time was the "T" rail section 6″ in height and the half and full grooved rail 6″ in height. The latter was found to be generally preferred by the city authorities though it is generally objected to by the street railway managers. The result of examinations at that time and of experience since, lead me to believe that the full groove rail will give better satisfaction under all conditions in the improved streets of our smaller cities where the pavements are wide, than any other rail section; aside from the "T" section it is the nearest center bearing; any kind of a pavement can be laid close to it and flush with the top surface of the rail; it affords no obstruction to the free use of the street by vehicles and it affords no tramway for the wheels of heavy loaded vehicles to track on and obstruct the free use of the street car track.

There is a great deal of trouble coming from the loosening of the paving material along the rails and over the ties of street car tracks, and all pavement covering the space occupied by a street car track foundation should be laid close, with interstices filled with paving pitch or grout, so as to make it impervious to water. Asphalt or McAdam cannot be successfully maintained along the rails of a street car track without a toothing of block pavement, of stone or brick, to prevent vibration of the paving material.

While I am unable to advise you how to lay the ideal street car track, I have seen so many poor ones and so few good ones that I will give my idea of how to lay a reasonably permanent and economical track. Sub-drain the roadbed with

drain tile laid directly under the track, with the trench filled with some coarse material, gravel or broken stone; this drain should be laid 3′ below the grade of the track. Upon the sub-grade lay a foundation of hydraulic cement 6″ thick and 2′ wider than the length of ties. Whether this concrete foundation should extend in one sheet the entire length of the track or only 12 to 15″ in width, for the support of each tie must be determined by the amount and character of the traffic; of course the former is better, but I have obtained good results from the latter. The surface of the concrete base should be from 2 to 2½″ below the bottom of ties; this space is required for ballast and cushion, and it should be uniform, as a variation of the ballast and cushion permits unequal settlement and too much vibration to the rail. Upon this foundation lay white oak ties 2 ft. centers with a full groove rail 6″ high, weighing not less than 60 lbs. per linear yard, without cross rods or flange braces, with long splice bar fish plates that will fit closely against the flange of the rail. These small things are mentioned as there should be nothing projecting from the rail that would prevent laying the pavement close to it, if there is, just so sure will the paving get loose and your pavement be seriously damaged. I recently saw 2½ miles of apparently splendid track laid with heavy 70 lb T rail in a new pavement, pavement and track having been down less than two years, and 70 per cent. of the pavement between the rails and for one foot on either side, was entirely out, and simply because these small matters were not attended to. Now to complete the track construction, the ballast should be fine dirty gravel that will pack, and after the ballasting is done and the track lined and re-surfaced it should be operated sufficient to detect any poor tamping and ballasting, then re-surfaced and lined and the whole space between ties concreted and very thoroughly tamped on top of ties when the space is ready for the paving surface, which should be made impervious to water and kept so.

The question of properly constructing, in connection with an electric street railway track, a sufficient and permanent return circuit, or in other words to prevent electrolysis, would require a paper in itself of considerable length to describe the

various methods used, and as this question is to be discussed and considered by experts I will attempt nothing further than to explain how and what I did to prevent electrolysis, and I assure you it was a bad case, on about a mile of double track road in this city. When the track was equipped for an electric road in 1888–9, the rail used was a tram rail, weighing about 26 lbs. to the linear yard, laid on a longitudinal stringer. This was bonded at every joint with a No. 6 copper wire and one No. 6 supplementary wire laid between the rails of each track. After the road had been in operation about two years frequent defective water and gas service pipes were found, causing the water and gas companies much annoyance. This continued for about two years with frequent leakages in service pipes before the cause was fully agreed upon. Then several remedies were proposed and tried, but all, I think without any effect. At this time the street pavement and the track in it required re-construction and the matter was taken up with a view of making it a return circuit, which was done by bonding each joint of the 60 lb. rail with two and three No. 00 copper wire, with a supplementary wire of one No. 0 and No. 00 wires between each rail connecting with the rail bonds and cross-connecting every 90′. The supplementary wire was put in voluntarily by the street railway company. I believe sufficient rail bonds will answer every purpose, as a 60 lb. rail is electrically equivalent in carrying capacity to one square inch of copper if the capacity at the rail joints bonds is so as to make its capacity continuous; with a double track we have a return circuit equivalent to 4 square inches of copper. From this return circuit, rails and supplementary wires were connected with 8 No. 00 wires carried over head and connected directly to the dynamo at the power station. Further than this as the earth will, under some conditions, take some of the return current no matter how great the return circuit may be, any part of the current that takes the ground in preference to the return circuit provided for it, will naturally find its way onto the underground pipes, and while it may travel upon the pipes for miles without doing any damage, when it gets near the power station it will go back to the return circuit and thus

cause electrolysis of the underground pipes where it leaves them for the track and return circuit. To prevent this and take away any possible current that might be flowing over the underground pipes, I put up an overhead return feeder for about one-half mile each side of the power station and every 300 or 400 feet connected it to the underground mains by tapping the same with a brass plug screwed into the pipe and the wire soldered onto it. In this way any current flowing along the underground pipes will take the path of least resistance which is the overhead wire, instead of going from the service pipe through the ground to the rail. I have since examined one pipe in the center of the danger district and there was no perceptible effect of a current passing from it or over it.

The President.—These two papers are now before you for discussion. Perhaps Mr. Ames can give us something of interest as to what effects you have suffered from electrolysis in Grand Rapids.

Mr. Ames.—I have not heard any complaints in regard to it. The Street Railway Company asked permission to connect their wires with the water pipes, when they first began to put in the electric roads, and the permission was denied them; I have heard of nothing serious occurring from electrolysis.

Mr. Sears.—How does your system compare with that outlined by Mr. Roberts?

Mr. Ames.—The ties are laid on the dirt, on the earth foundation. We don't put any concrete underneath. The construction of the car tracks is entirely in the hands of the company. The city has nothing to do with it. That is, we don't do the work. But in laying pavements, we concrete all around between the tracks, six inches deep. The track sometimes settles—in fact it almost always does; in many of our tracks, you can count the ties as you pass over the surface of the street.

Mr. Granville.—What is the nature of the soil?

Mr. Ames.—I think we have everything on the face of the earth, though it is principally a gravelly soil.

Mr. Granville.—It occurred to me, from what Mr. Ames said, that they had no trouble with electrolysis, that perhaps some of this trouble might be accounted for by the nature of the soil upon which we build these roads. In this city, you know, it is nearly all clay soil, and we have a great deal of trouble, and I presume that fact could be demonstrated by finding whether they have the same trouble in other places where the nature of the soil is the same as ours. In Grand Rapids the soil is different—perhaps they don't have that trouble in places with that kind of gravelly soil.

Mr. Ames.—I might say that there is a small amount of electrolysis going on—I have noticed some small pieces of pipe in which there was electrolysis taking place, but we have had no serious breaks in the mains, and therefore no very careful investigation. Of course we do not know to what extent the pipes may be injured.

Q.—I would like to ask Mr. Whittier the difference between the two soils.

Mr. Whittier.—There is some difference, but it is very slight.

Mr. Roberts.—Electrolysis is by no means confined to the Saginaw Valley or Saginaw. It was one of probably fifty places where electrolysis started about the same time. In Milwaukee they had substantially the same trouble that we have here, except that it covered a larger area and was not as severe, but it damaged their pipes. The remedy suggested and adopted by Mr. Benzenburg was to connect the water mains with the track, with galvanized iron wire—⅜ inch wire—wrapped around the pipe and I understood from him that there was no special care taken to get a connection of the metals—no scraping of the pipe or soldering the wire on the pipe, but they made these connections so as to equalize the potential—keep it the same on the rail as on the pipe.

The trouble here and in other places, is in the current passing down through a motor car, through the wheels to the earth. If the rail is an ample conductor to take it back, it will take it pretty much, but there will be some leakage, and that will spread out onto the pipes, and may cut across lots. Our

power station is located on Washington Avenue, about a half mile south, and the other lines run out east. I know that the current is traveling across on the pipes, following the blocks around and across, near the power station. When it comes there, it does not, as at first supposed, cut across lots to the power house, but it follows in from the main on the service pipes, to a point immediately under the rail, and there it goes to the rail, and at that point is where electrolysis takes place.

Mr. Sears.—I like Mr. Robert's paper; it is very concise and well stated throughout, and his suggestions are very good as to the construction of street railway track. There are one or two things I would like to ask him. After putting in the foundation, in proper form to eliminate the vibrations—how do you protect your tracks on either side? I don't think your method is quite full enough.

Mr. Roberts.—No, we have not complete control of it, but it is about as good as we can get where we haven't it all to say. It is the same with us as with Mr. Ames. The Common Council gives the Street Railway Companies ordinances without much regard to the future, except that they give them for about the natural lifetime of a man, thirty years, and the details of constructing and operating the same, and taking care of the return current and all that sort of thing, are lost sight of. I never saw in an ordinance, a mention of a return current until it was put in the ordinance here, less than a year ago.

We use here a concrete foundation, 12 inches in width, under the tie. It would be better to get a continuous sheet of concrete, but we have been able to get the 12 inches, and it is doubtful if we could have gotten the continuous sheet. In laying the rail, it should be independent of the tie except as it is spiked onto it. The braces that are usually put on, the cross rods sometimes put in, and the fish plates that project outside of the ball of the rail, all of these, it is hard to fit the paving material around these projections, and as Mr. Ames said of Grand Rapids, you can count these projections on the surface of the pavement.

Mr. Sears.—About a year ago I was talking with Mr. Hawks on this topic—he is manager of the Street Rail-

way system in Detroit. Their soil is quite a good deal like ours, and he was at that time running a system of levels, to determine whether the pavement was going up or the road down. He said it was more difficult to keep that in surface than a road carrying engines. He said we did not use ballast enough, but he used the system of ballast described. They dig a little trench for each tie, eight to twelve inches wide, and it is a concrete tie, laid under the real tie, covered with the cushion of ballast. These little cuts, undrained, receive more or less water and in the winter time that is pumping up and down.

Right here I want to call Mr. Roberts' attention to the fact that on two blocks on Genessee street, they have placed a foundation such as described Last spring there was a hollow about one-half foot deep in the center of the street; from this vibration there are more or less cracks, and the water finds its way into pools, and the frost will cause a change in the surface.

Now it seems to me that on clay particularly, we should put a layer of ballast or gravel under this concrete—that is, form a sub-drainage, connected with the sub-drainage he has described; the sheet of concrete should be continuous, and the city should compel the same. I would like to ask Mr. Whittier whether he considers Mr. Roberts' precautions against the return current, ample?

Mr. Whittier.—No sir, I don't. We have had five or six years to develop diseases in our piping that have been sufficiently serious to require marked repair. That same action has been going on all over the city and in time will break down all the pipes that come within the range of the carrying back of the current of the power house, and the only remedy I can see is the one which Mr. Roberts suggested, in his copper return, in the air. The expenditure of a small amount of money by the street car people, as compared to their present construction, (for they have their poles and cross wires in position) would be sufficient to put up a double trolley wire system, keep the thing above ground and let the people have their own property unmolested.

Mr. Sears.—I would like to call upon Mr. Brown, who has paid a good deal of attention to the construction of tracks.

Mr. Brown.—I know nothing about electricity. On the F. & P. M., my experience goes to show that we must have some drainage. We must get the water off the track as quickly as possible, and it is necessary to have a reasonable amount of ballast in order to do that.

On three different occasions since 1867, the track between here and Bay City has been washed away for four or five miles. The road bed was originally clay loam—blue clay—and in rebuilding the road, they would not give us time to put in sufficient ballast, and wherever it would wash out, you would find a hole perhaps eight inches deep; the result was that whenever there was a rainy time, we had a wet track, the mud would fly, and the only way to overcome it, is to get ballast enough to prevent this clay from rising up between the ties and have a uniform surface. Any trench that pretends to hold water under the rail is going to make trouble; that is why I think the system of trenches on the street car track is wrong. I think as Mr. Sears says, that the concrete should be made continuous, and in addition to the sub-drainage, there should be some sort of ballast underneath, and then if possible, make the surface impervious. With a dry surface underneath these ties, I don't see why the track should not remain as good as in the first place.

Mr. Appleton.—I think one of the greatest troubles about this is that when the charter was granted to the railways, very little was known of electricity. They were given a charter for thirty years, and agreed to pave inside the track, with the same kind of material employed by the city outside the track.

Now when the trolley car supersedes the mule and horse car, and heavier cars are used, there is trouble. We cannot get the street car company to do anything about putting down concrete under the pavement, nor they won't pave, and the whole matter with us is now in the courts. That new street that was paved last summer, we have a curbing of about a foot outside the rails; they are light rails—altogether too light. First of all there was a strap rail, now they have a T rail, and

there is nothing under the ties but dirt and the track is simply abominable. We expect to put in something like a mile of brick pavement, and I hope the matter now in the courts will be decided so that we can make them do something. It is a continual struggle there, to get the Street Car Company to pave, although they have agreed to do it—it is in their charter.

Mr. Sears.—Wouldn't sub-drainage, and a thorough coat of ballast, well applied, without the concrete, do there?

Mr. Appleton.—I have no doubt of it. They have no drain, no ballast, and while the city has two rows to run on each side of the track, it has only a single track in most places, but there is no drainage or anything else.

Mr. Hodgman.—Vote for Pingree.

Mr. Roberts.—I heartily agree with Mr. Sears and Mr. Brown in regard to their steam road track; of course they are at it all the while. If you have a foot of ballast, it is constantly settling, and you are constantly repairing it. I don't believe you can maintain the surface of the pavement over the foundation of a street car track, laid on ballast, no matter how well you drain it or how much ballast you put under it.

Mr. Sears.—You can keep the water out though.

Mr. Roberts.—Take the ties that are seven feet long, laid with three to four inch tiled drain, three feet below, filled with gravel or sand, which affords sub-drainage good enough; that takes the water away.

Mr. Appleton.—It would take a good deal of work and material to do that.

Mr. Roberts.—Now then, suppose we have 12 to 15 inches in width of concrete under the tie, I admit it is not all we would like, and while it will answer for some streets, there is some traffic in this city where it ought to be better, but it is more than a concrete tie, Mr. Sears. Your tie would be an independent piece, put in there, but the excavation is made and the concrete is tamped in there, it has support on the sides that a tie could not have, unless you tamped the tie on the sides, and then it would not adhere as concrete would.

Mr. Brown speaks of the tie binding and making a bed, and between the ties, the clay coming up. Now that is just

the case in the street car tracks, but with a concrete bed six inches thick between the ties, 18 inches in width, doesn't it help to hold that clay down? And if it helps to hold the clay down, it helps to keep the foundation of the tie up. The continuous sheet is better, but of course we must take what we can get. As regards the tracks in Detroit, I think Mr. Sears is mistaken about the concrete trench.

Mr. Sears.--That was a portion of the track when they first commenced.

Mr. Roberts.- On Woodward Avenue the track is laid on a continuous sheet of concrete. A little past the City Hall, on Woodward Avenue to Jefferson, they excavated, and put in from four to six inches of fine gravel under the double track foundation. They did this eighteen feet in width. They put on there a cobble stone pavement, laid and tamped it. They put on top of that a six inch bed of concrete. Over that they laid six inch ties and concreted between the ties and above the ties three inches. They had there in the neighborhood of twenty inches of foundation with lots of ballast, and twice a year, just as regularly as they could get the asphalt companies there, they repaired the asphalt surface, along the rails of the track. That is necessary owing to the vibration; the best construction yet, if it were practicable, would be to lay your tie in concrete, but I don't believe that that would be practicable, do you, Mr. Brown? That is, you couldn't get your surface and your alignment with any reasonable expense.

Mr. Brown.—You would have to get your alignment on the surface before you put the concrete on, if you did

Mr. Roberts.—It could be done, but it would be a great deal of expense, would it not? That would be better, but as that I think is impracticable, then take as little ballast as you can get along with, and surface up your ties; that ballast, with the concrete placed in between the ties, is cased in between the tie and the concrete and is just as good then, as the concrete. It cannot get out, either down, on the side or up.

Mr. Brown.—That is the construction they have in Detroit now, is it not?

A.--No sir, not that I am aware of.

Mr. ——— Out on Jefferson Avenue, where that electric motor was used, I noticed that the ties were bedded solidly into the concrete, and the surfacing and aligning was done before the concrete was put in. The ties were blocked up with solid matter before the concrete was put in, and I should judge from four to six inches of concrete was used.

Mr. Duncan is a resident of that city, and probably has noticed the construction.

Mr. Duncan.—I noticed when they were laying the pavement, and welding the rails, but I understood it was a continuous sheet of concrete with a thin coat of ballast.

Mr. Roberts.—Our Secretary has referred to Mayor Pingree. I think the condition of the street car tracks in Detroit, their bad condition, and the thousands of dollars that have been wasted by destroying pavements—(the President of the Board of Public Works informed me that the repairs on Jefferson Avenue amounted in two years to $67,000, caused by defective street car track construction) I think that they can pretty much be laid to Pingree's door. About the first thing he did was to require Mr. Hawks to cut the ties off close to the rails. You remember that, Mr. Sears—they said they had a shoemaker for a mayor and he was telling them how to build street railway tracks—and that has been the case all the way through, and I don't believe we want any Pingreeism in making our ordinances for street car tracks.

I think it would be a proper thing for this society to appoint a committee to take up the main features for street railway ordinances. It is needed now probably more than ever before. Every little town is trying to get an electrical street railroad, and as long as bonds can be sold and money raised as it can now, they will get them, because they are building them to bond them rather than to operate them, and these little towns could be protected if there was something they could refer to, and if every engineer in this society had something substantial laid down, that he could advise putting into an ordinance, it would help every engineer that hereafter does work in connection with street railways and every citizen of the villages and cities of Michigan.

Mr. Skeels.—How long has this system that you speak of, of concrete tie under the rail, been in use here?

A.—Two years.

Q.—What is the practical result of it, with comparison to other constructions?

A.—Well, I think this is about the first; Detroit put in concrete under ties a year or two before that, and it has done pretty well. There are two places here in four blocks of brick pavement—two places where the concrete weakened and the brick separated—but these are the only defects that have developed so far, sufficient to raise the pavements.

Mr. Appleton—Is that over six inches of good, well put in concrete, where the ties came up?

Mr. Roberts.—Understand, there are two ties in this distance of 1,400 feet of track. That would occur by not tamping the ballast under the ties.

Mr. Sears.—This foundation that Mr. Hawks put in on Woodward Ave. has been placed since I had this conversation with him. That reveals some points in regard to vibration. I want to ask whether, if after all, this concrete tie, with the cushions of earth between, isn't the best to prevent vibration; to deaden it? I believe that a good layer of gravel, Bad Axe gravel, thoroughly sub-drained, is better than your concrete.

Mr. Appleton.—It don't answer with us at all. I would rather take six inches of good concrete, well rammed, well made, well proportioned, and about two inches of cushion on it, and take my chances on keeping the ties all right. I think that is Mr. Roberts' idea.

Mr. Roberts.—Yes, that is my plan.

Mr. Sears.—In this connected sheet of concrete, wouldn't the vibration be greater than if it were cut in two at intervals?

Mr. Appleton.—I think that sub-draining, putting in good drainage is a very important thing.

Mr. Brown.—In regard to the ties working loose; isn't that likely to occur from careless workmen putting in this concrete? I observed some work this summer, where ties were being put in, that in some places the concrete was so high that it didn't require any ballast; in fact, it needed rounding off. In other

places, it needed perhaps two or three inches of cushion. It should be uniform, not half an inch in one place and three inches in another.

Mr. Roberts.—That is a question on which I laid some stress, in my paper.

Mr. Brown.—I did not hear the paper.

Col. Muencher.—A good many of the street pavements in Grand Rapids were laid on gravel. Probably some still remain, and there may be street railway tracks laid on them. I would like to ask Mr. Ames if he has observed how the tracks operate that are laid on these pavements, or if there are any left?

Mr. Ames.—Grandville Avenue, about a mile long, which was paved two or three years ago, was paved on gravel. The street railway track has the same kind of foundation, and the ties are quite as perceptible on that pavement as on the others. The track is in the best condition where we have concrete across the street. In some places, the Railway Company was allowed to put in broken stone, and the spaces between were filled as well as they could be, with the sand. The sand has settled, or the broken stone, and has left those pavements in particularly bad shape, and since then the Board of Public Works has insisted on putting concrete entirely across the street, and those are in better condition. The pavements have to be torn up around the joints frequently, and then when it is put back, it is never as good as on the start.

While I am on my feet, I might say that the remedy for the street car construction, I think, and for the electrolysis, is for the city to own everything that goes into the street. Let the street railway companies do the operating, but let the city own the gas pipes, water pipes and railway tracks. Mr. Elder, do you experience any trouble in Kalamazoo, with electrolysis?

Mr. Elder.—We have not had much trouble with electrolysis, as I know of, but the East Main Street pavement, that a year ago last fall was laid on gravel—sand and gravel—with the track laid on three inches of concrete, has not been at all satisfactory. The tracks are the roughest riding in town.

The President.—Col. Muencher, have you noticed any bad effects from electrolysis, in Manistee?

Col. Muencher.— No sir. Our street railway there has only been in operation two years, and we have not seen anything of the sort yet. There is no telling how soon we may. Our soil there, where the railroad is laid, is altogether sand, very deep, and it is possible that may have some little influence. Our pavements are all block pavements, laid on sand, and wherever the street railway tracks are, they are pretty bad, though they are not much better anywhere else.

Mr. Elder.—There is no settling of pavements at all, where they are laid on sand, but where there are tracks, they are in pretty bad shape with us.

Mr. Roberts.—I don't care to monopolize the time in talking on this question, but I think Mr. Whittier could tell us a great deal more, if he would just move his chair up there near the President, or stand up there, and talk in a general way. We could get a great deal of information.

When the street railroads were first equipped with electricity, I believe that the men who had brains enough to invent the system, did as well as they could in providing for the return circuit—it wasn't questioned at the time, was it Mr. Whittier?

Mr. Whittier.—Yes sir.

Mr. Roberts.—I never heard it questioned at that time.

Mr. Whittier.—As to the use of the earth for the return circuit, you mean?

Mr. Roberts.—Yes.

Mr. Whittier.—No, that is something that has come up since, especially the question of earth resistances,—getting away from the old theory that the earth was so large that it offered no resistance—so that this No. 6 wire that was used for binding and supplementary wiring was considered ample. It was put in there as a part of the equipment; they didn't consider that it had much use. The first road built I believe in this part of the country, was down at Port Huron, and while they constructed on an old horse railroad iron, strap rail, they placed under the joints a thin piece of metal to make connection between the rails. That was the first road I believe, outside of the Canadian one at London, which I think was the

first railroad on this continent. Next to that is the Port Huron development, and they recognized the necessity of lowering the resistance, and the autopsy proved that it was necessary. We are still laboring under a number of conclusions I think, that would be proven beyond any doubt to be specious, but which we have accepted as theories simply because no better can be advanced.

Col. Muencher.—I would like to ask Mr. Whittier if he can give us any idea as to the extra expense of equipping a road with sufficient return wire, dispensing with these bonds and everything else connected with the rail.

Mr. Whittier.—I never made any figures on that, but my idea of the matter is that the cost of any piece of machinery is not in the first cost—it is maintaining and keeping it up, and if, at the end of the year, the accounts have been kept accurately, I believe that the reduction of horse power and the replacing of loosened joints, and the diseases that come from bonded rails, if figured against an overhead trolley wire, that the companies would be largely remunerated in the change by these things for the first cost of the wire. But I believe that the reason why this has not been adopted is that some clever Yankee conceived all this some years ago and put a patent on this return trolley wire for carrying back the current, and the systems now in use, being largely hawks, preying upon what they can, have not adopted it. Take the construction of the railroad in this city as an engineering job. It was the laughing stock of engineers. They came here and took a little light rail that was light enough for a poor horse service, and the wires—well if they had been spiders and stuck their wires across the street with glue, they couldn't have been much poorer. Such a plan is short sighted; in the cost of maintenance, they have spent two-thirds enough more on this road as it is, than to have gone on and put in a decent construction in the beginning. But they came here with the idea of selling out the stock, and the result is what we have got. We must do the best we can with it.

Col. Muencher.—Every engineer knows it is possible to build a plant substantially in the first place, but I wish to draw

out the fact that, in the long run, a company would save money by putting up a return wire in the first place; that does away with electrolysis and the repairing of bonds, and a vast amount of maintenance work that otherwise cannot be dispensed with. As the knowledge of this electrolysis becomes general, these railroads will have to pay for the damage done, unless as in Grand Rapids, where they were cunning enough to foresee and ask for the privilege of connecting their system with the pipe, and in that case they would be using the water works system as a conductor, which, in the manner in which it is used, would not materially hurt it, because it would be simply used for carrying the current, and no intervening resistances would cause breaking down of the pipes.

Mr. Whittier.—If they were to connect the pipe at the power house, they would have to follow it through with a systematic measurement and a mapping of the water, gas and sewer mains, from a resistance basis, to find the short resistances over which the current would flow. The damage done is in the movement of the current from one system of piping to another. There you are decomposing the metal, so, should the city utilize a series of taps on their mains and make good connections and maintain them,—and that is a hard thing to do,—it opens a law point for any form of union that I have yet seen, unless it has been this electric welding and binding of rails, which makes the two materials a part of each other without increased resistance,—will break down in time. It opens a seam in the rail, and each coupling has an action of its own, laying aside the secondary action of the heavy current.

The President.—Mr. Whittier, I unders and that in Europe, in several cities, they are using, successfully storage batteries on street railways. Now, I would like to ask you as to that, and if the practice in our country is behind the times as compared with theirs?

Mr. Whittier.– The use of the storage battery is largely based on the source from which you can draw money to pay for the expense of running it. It is a question of dollars and cents. Every time you convert one type of force into another you have left something behind. It is like the man who tried

to carry molasses in a series of ten pails—he kept changing from one to another, and when he reached his destination he did not have nearly as much molasses as when he started. Every conversion of electricity makes a loss of from nine to twenty per cent. of the whole. Suppose you have 100 H. P.; turn that power over on a dynamo and you have lost 9% of the actual power, even with the best forms of dynamo known to-day, not speaking of the difference between electrical horse power and actual horse power. Then we turn that over a system of wires into a motor—there is another conversion and another loss, so that during the changes from the initial point to the point of work, there is only about 41 H. P. out of the 100 utilized. Now, in having a storage battery, which is another type of convertor—another molasses pail—you have still less horse power than was originally created. In cities, where the houses are 10, 15, 25 feet fronts and six to ten stories high, instead of, as in our country, where they are 60, 90, 120 feet apart, and only one or two stories high, you can draw people enough to maintain a secondary or storage battery. It is simply a question of dollars and cents.

The President.—The use of that, however, would entirely obviate the evils of electrolysis, would it not?

A. It would be independent of overhead trolley wires.

Mr. Roberts.—I think there should be a distinction made here between the return circuit of the double trolley system that Mr. Whittier speaks of, and the other. You are referring to the double trolley system entirely. I think Col. Muencher has in mind a return feeder.

Col. Muencher.—I am not sufficiently acquainted with the terms to know what you would call it. What I mean is a wire carrying back the currents to the power house without the intervention of the rails.

Mr. Roberts.—That is a double trolley system. You take it off or put it on to the circuit; put it on to the return just as you take it off. That is maintained parallel and close to the trolley wire; we don't want to add any more wires to our streets. Another trolley means stronger supports, closer together, a

third more guy wires at every intersection. This can be conducted as well on a feeder along the poles, can't it?

Mr. Whittier.—No, you have got to reach it with the trolley.

Mr. Roberts.—Suppose you reach it through an insulated wire, connecting your wire at every hundred feet with your rail?

Mr. Whittier.— If you can maintain a good connection with your rail by the use of two different metals, or can run out from your iron rail, an electrically welded body of cross-section sufficient to carry it, it would be all right; the resistance of iron is much higher than that of copper. It takes a piece six times as big to carry the same current.

Mr. Roberts.—Now, then, we are speaking of a track laid on a good foundation. You are thinking of an old track where the bonds were broken about once in every thirty days. I noticed recently that Edison has compounded an alloy that can be used with perfect safety for a rail bond without this oxidization at the joint. But, allowing that there is no metal suitable for a rail joint bond, if we could connect three rails, we could probably weld three or four rails, and connect each one of these with an overhead feeder to be strung along on poles, and I think you would be just as safe as you would with your double trolley system.

Mr. Whittier.—Yes, but it would cost more; you must consider the company a little bit. You can not, simply because you have the power, say, "You have got to do it our way." In construction, it would be cheapest for the company to put the wires within reasonable distance of each other, and use one extra trolley pole in place of carrying all this wire from the track to the side wire—the same cross section, because it has to do the work of carrying the current at the side of the street, and while it is necessary probably to put in a few more supports, it would not increase the number of wires materially in a mile of double trolley system. I don't know what the proportion is.

It would be adding one more trolley wire and no more supporting wires, simply increasing the size of the cross wires, for the reason that you can stretch a wire between poles with about the same quantity of sag, in any number. It is a question

of sag, and how it will stand the distance between the poles, rather than of the amount of support. You might increase the number of cross wires a little bit, but I don't know as that would be necessary. There is more power in the wire as used than is necessary to maintain that little weight.

Q. Should not the return trolley wire be larger than the out going wire?

A. Practically, less. In carrying out your idea, you must keep watch of your dynamo tender to see that he don't ground one side of the dynamo; should three or four of these feeder connections in the return break down, and a spot in the track increase the resistance, he would try and help himself out of that place until he could fix it, and it would not be long before there would be a great deal of that. It is a temptation to use a makeshift when a railroad system is dependent on the use of its power.

The President.—Mr. Whittier, in the use of this return trolley, or motor trolley wire, for the return of circuit, is it necessary to have a contact between that and the dynamo the same as I understand is now effected through the rail? In other words, would you have to have two trolleys?

Mr. Whittier.—Yes, one to take off and the other to put back—to keep up the circuit through the motor.

Q. Then you couldn't, in case of parallel tracks, return the circuit on one of the wires?

A. You mean the switching?

Q. No, suppose you have parallel tracks and a trolley, with single trolley wire for each one. Could there be an arrangement of trolleys effected so that the entire circuit could be carried in those two wires?

A No, I don't think so. When two cars passed each other, it would be necessary for the operators of the cars to shift their trolleys, one over the other; it may be that some Yankee will fix up some scheme to shift them by each other, but it would necessitate their reaching off at an angle from the car with their trolley, and in rapid transit there is not time for the shifting of trolleys.

Q. Then so far as the general knowledge on this subject

goes, if the return circuit is taken from the earth, it necessitates the double wiring?

A. Yes, more than double wiring. You would have to put all these feeders into the return wire, from the rails, say at every ninety feet, as was suggested.

Mr. Roberts.—That is for a return feeder. I believe the President was speaking of the double trolley system—that is, two trolleys and two trolley poles. The point I make against more wire is because in every city the clamor now is, to get the wires under ground. In Detroit they are putting them under ground; it is being considered here.

The return feeder, I believe, should be larger than the trolley wire which takes the current out; as I understand it, it goes out under force and comes back without any force. For instance, you will receive a certain amount of water through an inch pipe that is tapped to our water mains and pumped under heavy pressure. You open your faucet and let the water flow, and you must have a larger pipe than one inch in diameter for it. That, as I understand, is a parallel case. The current goes out with so many amperes—so much force behind it; it comes back without force. It must have a larger path and a larger wire.

Q. Won't the dynamo draw it back with the same force?

Mr. Whittier.—The quantity of current remains continuous. Mr. Roberts is right, that any electrical construction necessitates the maintenance of the cross section of the wire sufficient to hold resistance within reasonable bounds, and in carrying out two trolley wires from the station, the ends nearest the station would be the largest, for at the extreme end there would probably be but one car at a time; it would not require the same quantity of copper to carry the current for the propelling of one car without material dropping of potential; that is, when changing the pressure, as you get nearer where most of the work is done, you require greater cross section to carry your current. The taper should come from the station in both cases.

Mr. Ames.—I wanted to ask if the city owned the railroad tracks and the water pipes and the gas mains, and as electroly-

sis can only take place where the current leaves the ground or goes to the main, that is where the path is broken; if the path is made of ample size, sufficient capacity, why isn't it better to use these things and use them freely? At the power house you could construct a sufficient chamber underneath the street, through which all these pipes would pass, and free access could be given to it, and it would not be a large expense to construct a number of these places along the street, and you could use these things freely.

A. The disease would still remain because you are unable to maintain good connection between your water system and electric system, and the continual changing of water piping would necessitate a continual measuring of resistances and a changing to the lowest points for distribution of the current. You would have to keep after it all the while to know what pipes were being used. It would necessitate not only considerable labor, but skilled labor. A man who can not only make the instruments for measurement, but who was a fair draughtsman, and who understood the thing, would be needed to keep it in condition. Even then there would probably be a good many diseases which would creep in. A poor piece of piping would develop in itself some trouble, and reduce or increase the resistance, which would mean continual watching.

Mr. Ames.—I don't mean to depend on that entirely, but to use that after the construction of the road. There are certainly strong objections to putting in more wires in our streets. We want to get out what we have, but after making the road and the bonds in the best possible manner, why wouldn't it be a safety to the pipes to connect those, too.

Mr. Whittier.—If you take up that subject, it runs into the possibility of the city owning a conduit for the carrying of wires, and charging a rental to the private corporations. I don't believe in a city entering into any line of business which anyone else can do, as long as it does not infringe on personal rights. You open up a large question when you ask the city to do any type of business for the city.

Mr. Ames.—The matter of street railway tracks is as much a matter of public interest as pavements. No private company

pretends to make the pavements. The city must build and maintain them. The maintenance of a street railway track is as much a matter of necessity as water, and gas and electric lights are going that same way. I see no reason why the city should not own everything that goes into the streets. Leave the operation to a private company.

Mr. Reed.—According to the amount of power expended in the plant, does the electric light power have the same effect of electrolysis that the street railway does?

Mr. Whittier.—With but few exceptions in the history of electric lighting here, no engineers who have laid out electric lighting stations used an earth return, only in case of poverty where they did not have the money to buy the wire. They soon got out of it because it cost money to add such enormous resistance to their circuits as compared with the number of lights they were able to show. Where one side of a line is grounded, the possibility of killing people with high potential currents is very largely increased when used in the ground. The man simply touching the outgoing wire that carries the current to the lamp, or in trimming the lamp, may make a short circuit, and he is gone; as has often been the case. I think there are some three or four hundred people now on record as having lost their lives in that way.

I don't believe in unnecessarily persecuting corporations who own franchises, but where there is an evil existing, there ought to be something done in the legislative way. As I understand now, the various electric companies, whether intentionally or not, appropriate the property of others and with great damage to them, in order to effect a saving. As far as I am aware, in every state in this Union, there are statutory laws to restrain the running at large of vicious animals, which make a great deal of noise and give signs of their coming. People affected with contagious diseases are quarantined for the good of the public. Now, then, if there is a stray force running through the cities which gives no warning and is liable to cost the loss of life and destruction of property, it seems to me it would be a very good subject for our legislatures or city councils to take action upon, and effect a good deal of justice.

Mr. Duncan.—I would like to have a word on the subject that has been discussed. In the first place, I would like to ask Mr. Whittier about the conductivity of concrete, compared with earth?

Mr. Whittier.—I never made such a measurement, and I don't believe there is any data to be found, outside of the data of electrical engineering companies. It is a thing that could be ascertained very readily.

Q. Would you imagine there was very much difference?

A. Oh, there is some difference, yes. There would be a marked difference between the earth and the concrete, but both carrying moisture, it would not be so marked as would be supposed at first thought.

Q. Then in regard to the preparation of the street and the building of railroads for electrical transportation?

A. This has been going on in Detroit in perhaps a hundred streets in the past year. I have not followed the subject up closely, but I have had a good chance to observe different methods, and it seems to me that the up-to-date method, the best, is the one employed on Griswold Street, in which a gravel ballast was used, and on top of that a course of concrete; on top of this, iron ties were employed, and the concrete tamped under these; the rails laid on this, and then the concrete filled in up to the necessary height to meet the pavement. It seems to me that by this method of using iron ties, and fastening the rails to them securely by bolting, that some of the objections can be done away with, that have been spoken of, chiefly the one about the rails vibrating, and so tending to destroy the pavement. By imbedding the tie in the concrete it forms a solid mass, and having the iron girder rail securely fastened to it, you practically do away with any vibration. This is perhaps more expensive than the other methods, but economy is not always in the first cost of an article.

THE USE OF THE STADIA IN TOPOGRAPHICAL WORK.

BY ARTHUR BEEBE.

The use that modern engineers make of topographical maps is very limited, much more, in fact, than it should be; and this, I think, because of their high cost when made by the older methods, and the supposed inaccuracy of the method by telemetric measurement. It is surprising that prejudice and conservatism should so long prevent the use of the stadia for all topographical work, and that the use of topographical maps should not be greatly extended.

The most important engineering work at the present time is railroad location, and we will consider first its advantages for this work. The topography required for railroad location is for the purpose of securing easiest practicable grades, and reducing cost of earthwork to a minimum. Commercial considerations usually require that the line should connect certain points not far distant from each other, and a careful reconnoissance will decide about what the route will be. The actual location of the line along this route will depend to a large extent upon who is engineer, each having ideas of his own about it, which shows, I think, that there is generally considerable guesswork about it. The old English method was to make a complete trigonometrical as well as topographical survey of the route, including the surrounding country, and by the slowest and most expensive methods, but when we commenced railroad construction on a large scale in this country, we found this too slow and expensive for us. We therefore substituted running preliminary lines and located by cut and try methods, backing up and trying again until a satisfactory location was obtained, and very many lines were constructed with no more study than this. But with a demand for better work, more attention is being given to topographical maps, as aids to location.

The topography required for railroad location is a strip, say, one-half mile wide, covering the general route selected by the reconnoissance, and in ordinarily open country, unless nearly level, I would dispense with preliminary lines entirely, and substitute a complete topographical survey, made with alta-azimuth and stadia. The object of the preliminary survey is to obtain information, and it generally costs no more to obtain a correct map of a strip one-half mile wide, showing by contours correctly its hills, hollows and complete shape of ground, together with all important natural and artificial objects, than to obtain a single profile with transit and chain, which does not give as complete information as is desirable, for it does not tell us what the effect of a deviation would be, and we are inclined to accept the preliminary as a finalty, and to confine our efforts for improvement to adjusting the grade line to the surface, especially if, as is generally the case, the "General Manager" is finding fault with the expense of the survey.

The person that makes the final location should make the topographical survey, for he can thereby best study the ground he has to work on, and I do not believe in a paper location. There are other considerations than merely amount of cuts and fills; this will depend much on the character of the ground, and must be seen and noted. He should be provided with instrument having vertical circle reading to ten seconds at least, and a first class telescope of fifty diameters. He should have with him a recorder and an abundance of rodmen. Then following a main line as near center of strip as may be, he should select commanding points for stations, and cover the ground with sufficient number of observations to completely represent the ground and all important natural and artificial objects. Having finished observing at a station, and the recorder having computed heights of all observations, take your instrument box for a chair, and plat your work then and there, using engraved protractor sheets with parallel ruler or triangle and straight edge for transferring readings, and of course all readings from horizontal circle will be bearings, and not angles. Having finished platting, and lightly penciled heights of points observed, take your drawing board and visit all parts of the ground

covered by the observations, drawing in the contours with the ground actually before you, and you will probably find that many of your ideas of shape of fields, buildings, etc., obtained while standing at the instrument, were wrong. A portion, at least, of your rodmen should be well trained to the work, for you must depend upon them to select points for stations, and in the secondary work the greenhorn will consider nothing of importance except fence corners and buildings, which are of small relative importance. Your rate of progress will of course depend much on the character of the ground, level ground requiring no topography, and mountainous districts very minute measurements, but in ordinary rolling country from one to two miles advance can be accomplished in a day, so that the location can be projected directly on the field sheets with confidence. The measurements will be fully as accurate as chaining, and the heights will be practically as good as direct leveling, and there will be no more need of checking by independent measurements than with chaining, nor as much so if distances and vertical angles are read in both directions between stations.

But railroad location is not the only work for which the stadia is valuable. For locating contours for drainage purposes in a flat country it is the only practicable method, and surveys of large impounding reservoirs for town supply or irrigation purposes it brings cost of work down so that, with plane table, contours can be located at each foot of vertical height, and the gauge graduated to show the amount of gallons or cubic feet remaining in the reservoir at any time.

The present practice of the U. S. Lake Survey at St. Mary's river is to locate stations with theodolite and stadia, afterwards occupying the stations with plane table to fill in details, the tables being provided with telescopic alidades and stadia. As they have unlimited resources and boats of good carrying capacity for conveying instruments, the method works very well, but is not applicable to general use. The plane table is too cumbersome an instrument to use where much transportation is required. It is used on the Geological Survey with the old method of locating by intersections for large areas, and the compass and wagon wheel tally method of

traversing roads and taking details of topography. It has nothing to recommend it.

What is the best method of telemetric measurement? This is a much disputed question. My own experience is that the worst method is the movable wire, which is to be adjusted to read one foot on the rod for each one hundred feet of distance; it is a delusion and a snare. The wires should be fixed in the ring with the cross wires, and the rod should be graduated to correspond with the wires. Better still is the prismatic arrangement invented by Robert H. Richards, which projects the image of the lower point observed upon the target used as a starting point, in much the same manner as the sextant. With an instrument for measuring small horizontal angles to single seconds, the method with two fixed targets on a horizontal bar, introduced by Keuffel & Esser, gives very accurate results, and no correction of distance for vertical angle is required. It is adapted only to measurement between stations and other principal points in taking topography, and as it is not desirable to have two systems in use at one time, it is not adapted to general use.

To my younger fellows, I would say that if you will become familiar with the stadia, and use it in your topographical work, you will find you have a valuable addition to your instruments, and often a very present help in time of trouble.

THE USE OF THE PLANE TABLE.

WM. G. FARGO, JACKSON, MICH.

Believing that much misapprehension exists in this country regarding the plane table and its uses, the writer desires, briefly, to point out how this instrument may be of service to any engineer or surveyor having a mixed practice.

"For making a map the plane table is a universal instrument. It is applicable to all kinds of country, to all methods of work, and to all scales. For making a map it is the most simple, direct and economic instrument; its use renders possible the making of the map directly from the country as copy, and renders unnecessary the making of elaborate notes, sketches, photographs, etc., which is not only more expensive, but produces inferior results."

The general methods of using the plane table will not be considered here, as they are fully described in the text books on surveying. Much useful information with regard to the plane table and topographic work in general will be found in Monograph XXII of the U. S. Geological Survey, entitled: "A Manual of Topographical Methods," by Henry Gannett, Chief Topographer. This is a large quarto volume of 300 pages, about half of which is tables for the reduction of stadia readings, map projections, etc., etc. If the edition is not exhausted, a copy may be had for $1 by addressing the director of the U. S. Geological Survey at Washington, D. C.

Having occasion, within the past year, to make several topographic maps, covering considerable areas, the writer constructed a simple plane table, very similar to the traverse table used on the U. S. Geological Survey. This consists of a small pine drawing board, with a five-inch needle set into its upper surface near one edge. A spring lifter keeps the needle off its pivot except when in use; that is, the spring must be pressed down by the finger and held there in order to allow the needle

to rest on the pivot. This is an improvement over the usual screw lifter for use on the plane table, as one cannot travel about with the needle loose on the pivot, as often happens with the screw lifter. A brass bed plate is set flush with the under surface of the board, and tapped for a thumb-screw similar to those used in attaching a camera to its tripod. The wooden cap which protects the screw threads of a Gurley transit tripod was bored in the center to fit the thumb-screw, and the table mounted on the transit tripod. A wooden alidade, with open slit sights, completes the outfit, although, of course, a brass alidade is much better. The table is leveled with a detached level by means of the tripod legs. On rough work the table can be leveled sufficiently close by eye, by sighting across the top of the table at a distant horizon. It is oriented by using the needle which has a range of ten degrees each way from the zero line, which is parallel with the edge of the board, or it may be oriented by back-sighting to the last station or some other point already platted on the sheet.

For maps on a scale not larger than eight inches to the mile, many distances can be ascertained with sufficient accuracy by pacing or by counting the revolutions of a wheel, when not conveniently found by intersections. Section and quarter-section and eighth lines serve as bases and as checks on location by intersections. It is surprising with what accuracy one may ascertain distances by pacing, after some practice, especially along smooth roads or on railroad tracks. Along many railroads the station stakes at each 500 or 1,000 feet serve a useful purpose when using the traverse table, and a considerable belt of country each side of the railroad or highway can thus be covered without leaving the road. In an unsettled or timbered country it will be necessary to run some traverse lines with transit and stadia to serve as base lines and "control" for the plane table. If elevations are desired, a small telescopic alidade is necessary. The Casella type, used by the U. S. Geological Survey, seems well adapted, except for very large scale maps.

Maps showing marsh and lake outlines, streams, etc., for use in drainage assessments, can be rapidly and accurately

made with the traverse table described, and when the field work is completed the map is ready, except inking in or tracing. No tedious plotting of stadia readings in the office, where it is sometimes found, when miles away from the ground, that there is evidently an error somewhere. With the plane table there are so many chances to check in known points at all stages of the work that any error of importance would be discovered and rectified before leaving the locality.

Maps for use in court and working topographic plans for the location of the curved drives and paths of cemeteries, parks and suburban residence grounds, are cheaply and accurately made with the plane table.

With the simple traverse table described above the writer has had no difficulty in mapping a square mile of average Southern Michigan farm and timber land per day, on a scale of eight inches to the mile, and showing accurately all natural features and culture, fences, ditches, etc. Elevations are not shown except the more prominent hills and slopes by hachures.

There are, of course some drawbacks to the use of the plane table. If a large board is used, it is an awkward instrument to carry through brush or timber. It is not a convenient instrument to use in rainy or very cold weather, or in high winds, but as transit and stadia work is also dependent for best results on good weather, these objections are not so serious as they might appear.

REDEMPTION OF SHIFTING SANDS.

E. W. MUENSCHER, C. E.

A few months ago, while reading the "Transactions of the American Society of Civil Engineers," for December, 1894, the writer noticed in a paper by B. W. DeCourcy, C. E., on the "Improvement of Gray's Harbor," the following statement: "The neutral line mentioned, where the sand meets the silt of the river, indicates a deposit of sand brought in by the flood tide, but there is also another cause for this deposit, viz., the prevailing storm winds from the northwest and southwest. This traveling of the sand can be both seen and felt, but can be easily remedied by the cultivation of the *Arundo Arenaria*." This paragraph re-awakened a long slumbering interest in a subject which is of much importance to many citizens of this State.

Along the western and southern shores of Lake Michigan there are many long stretches of sand hills or *dunes*, some of which rise to a height of 100 feet or more, and extend for miles along the shore. These dunes are composed of very fine sand which has been washed up by the waves and then blown up and driven forward by the lake winds until its progress has been arrested by a tree, bush, large stone or other obstacle, around which it has accumulated in great masses. Some of them are covered and held in place by a thin growth of coarse grass, while others are entirely naked, and when the surface is once broken the sand drifts like snow before the winds, and the dunes often become crawling monsters, burying roads and houses, fields and forests, under their resistless and desolating tread. For agricultural purposes they have been utterly worthless, and, even when harmless, their barren, yellow slopes present a very bleak and desolate appearance, and make the scenery of some of our lake cities anything but attractive. The writer has often gazed regretfully on the forbidding-

looking ridges which surround and disfigure the city of his adopted home, and felt that if some practicable means could be discovered by which they could be clothed in living green, the relief to the wearied eye would alone sufficiently warrant the cost. But if, in addition to this, we could find a remedy for their destructive progress and a means of fitting these now waste ridges for the uses of agriculture, we should be well rewarded for the effort which had brought about such results. And if, still further, we could add the possibility that the same measures which would redeem these dunes might be used to cover with pastures and orchards and forests the worthless and uninhabitable sand plains and old choppings which cover so large a part of Northern Michigan, the effort becomes so much the more worthy to be made, for it might add millions to the wealth of the State. For years this has been only a dream, but, encouraged by the paragraph which has been quoted with a hope that it might possibly become a reality, the writer has been gathering such information as he has been able to obtain as to what has been accomplished elsewhere, and now lays it before this Society in the hope that some of its members may be able to make valuable use of it, and, perhaps, add to it from their own stores.

We are not alone in our possession of these undesirable features, though, until very recently, we seem to have been alone in our neglect of them. France, Holland, Prussia and Denmark, as well as some portions of England, Ireland and the Scottish Isles, have been cursed with great tracts of just such soil, which bear the various local names of Landes, Polders, Klittens, or Downs. Johnson's Cyclopedia, article "Dune," says: "They often do great damage by their inroads upon the country, the department of Landes, in France, having been nearly overwhelmed by them. The annual progress of the sand is estimated at 72 feet." These French dunes "extend along the Gulf of Gascony, from the mouth of the Adour to that of the Garonne, a distance of 150 miles, and have an average breadth of 3½ miles, covering an area of about 300,000 acres. Their extreme height is 330 to 350 feet. The advance of these sands had been going on for ages, cover-

ing up whole districts of farming lands and entire villages." Nearly the entire length of the sea-board of the Netherlands is a sand formation, which attains a width in some places of 5 miles. The area of this formation is estimated at 140,000 acres. Nearly the entire sea-board of Schleswig Holstein and the western coast of Denmark, to the extent of about 190,000 acres, is covered with what was, a few years ago, drifting sand. A great part of the Baltic coast of Prussia is covered by dune sands, which are known as the Pomeranian Downs, and embrace an area of more than 50,000 acres.

It was not till the year 1787 that the first attempt was made to reclaim these downs upon rational principles, and it is to M. Bremontier, then chief engineer of the department of the Gironde, that the credit is due. Since that time great progress has been made, and now not less than 230,000 acres of the French dunes, 100,000 acres of those of Holland, two-thirds of those of Denmark, and a large part of those of Prussia have been reclaimed, and the greater part is under cultivation.

The success of the system by which this reclamation has been effected depends upon the fact that "although the whole mass of sand composing the dunes may be entirely removed under the action of the wind, the transportation is effected grain by grain; that is, the top grains are first rolled away by the wind, and those next underneath coming to the surface are carried away in their turn, and so on. Therefore, if the grains on the surface are held in position, there is nothing to fear from those that are underneath, and the whole down is rendered immovable. A temporary immobility may be obtained by covering the soil with branches and boughs," but for permanent results resort must be made to living plants, and experience has shown that Nature is abundantly able to do this work if properly directed and aided by art.

It would seem, at first sight, that, as these dunes are composed apparently of pure sand, no plant life could exist for want of moisture and organic food, but experience shows that they all contain at least a small proportion of matter which plants can appropriate, and that the fineness of the sand

enables it to hold a considerable amount of moisture near the surface by capillary attraction. M. Goury discovered that upon the highest inland dunes, where the texture of the sand was the finest, perpetual moisture was present at a depth of 4 inches below the surface, while near the shore, where the sand was coarser, the line of moisture was a foot below the surface. The water from the dunes on the North Sea coast is brought by aqueducts into the interior, and the best water used at Amsterdam is said to come from this source.

With these facts as a foundation, the system of reclamation has consisted of two distinct operations: 1st, arresting the sands brought upon the beach by the waves; 2d, holding the already drifted sand of the dunes themselves by the production of vegetable growth thereon. The first is now usually effected by the building up of a new dune between the old ones and the beach, which protect the old dunes from the action of the winds while the process of reclamation is going on. This is accomplished by the use of what are called "palisades" or "fascines." The "palisade" is substantially a fence "made of boards about eight inches wide, and separated from each other by intervals of about one and one-eighth inches. When the sand is carried along by the wind it strikes against this obstacle and accumulates at its base; then, under the effect of its own weight, it passes slowly through the intervals left for this purpose, or, so to speak, it strains through the fence and deposits simultaneously on both sides. Thus a mound is formed and the boards gradually covered up by the sand." The boards are then raised and the process continues. "In place of board palisades, or jointly with them, 'fascines' are frequently employed, composed of stakes from five to eight feet in length, from two to three inches in diameter at the middle, driven into the sand twenty inches, and placed at intervals of twenty inches. These stakes are afterward woven together about twenty inches above the ground, either with brush from five to six and one-half feet long, placed end to end, or with marsh grass rolled in rope shape and about four inches in diameter. When this first woven work is nearly covered up with the sand which it stops, a second fascine

woven work, twenty inches high, is put on, and this work is repeated in the same way as fast as the sand is brought in until the woven work reaches the top of the stakes. Then the stakes are raised with clawed handspikes, and the same work is then recommenced. These artificial dunes finally reach a height which makes them an effectual protection to the dunes in their rear from any further encroachment from without. It is probable that along a large portion of the Lake Michigan shore the construction of this protecting dune will not be necessary, for the reason that the present hills have reached a height which would be a sufficient protection to the country behind them if they themselves could be protected from erosion.

The second operation in the process of reclamation, or the reclamation proper, consists in clothing the drifting sands with vegetation which will hold them in place. It has been demonstrated by European experience, that "the plants best adapted to cultivation on sand dunes, may be divided into two classes. The first embraces those trees and shrubs which have very long tap roots, diving down into the body of the formation for the sustenance which shorter rooted plants would not be able to find in sufficient quantities. The second includes such grasses and creeping plants as throw out numbers of interlacing fibrous roots, persist in pushing their tops above the drift which may cover them, root afresh at every joint so covered, and thus build up a hillock, throughout whose bulk their ramifying rootlets extend for themselves. The plants of the former class will not admit of much sand being drifted over them, and should therefore be used only where the movement of the surface sand has been stopped. Those of the latter class will not flourish to their fullest extent unless there is a constant fresh supply of the silicious particles blown upon them." They are therefore best adapted for the work of binding together these drifting particles, and when this work has been accomplished and the movement has ceased, they perish, and their decaying remains furnish organic matter for the nourishment of other and more nutritive and valuable plants.

There are several species of plants of this class which have

been used with more or less success, but the one which stands at the head of the sand-binders, having proved itself far superior to all others for the coast plantations on all the great works of reclamation, is the *Arundo arenaria* or *Psamnia arenaria.* This plant is known by a great variety of names as "mat-grass," "mat-reed," "mat-weed," "sand-reed," "beach-grass," "sea-grass," "marum" or "marrum," under which it has been used at many points on the coast of England, to reclaim sandy tracts. It is planted on the shore dunes of the Prussian sands, where it is known as "hugelrohr." It is the principal agent in the work of reclamation on the Danish dunes, where it is called "klittag" (sand sedge). Nearly all the dykes of Holland are covered with it and much of the drifting sand waste of that country has been reclaimed by it. It is there called "helm" or "dach grass." The French call it "Roseau de Sables" and now accord it the precedence for the beach plantations.

"It is a strong and rapid growing reedy grass, which throws out its roots horizontally and rears its leading stalks diagonally upward. It sprouts new roots and new leaf stalks from each bud covered by the drift, and thus spreading through the sand, finally binds it by a perfect network of vegetation. So far from being injured, it is seemingly refreshed by a shower of drift sand, and dies out when complete reclamation has been attained, and other plants take its place."

Mr. W. H. Hall, C. E., in a report to the Board of Commissioners of Golden Gate Park, San Francisco, to which the writer is indebted for much of the matter of this paper, says: "It should be raised from seed in the moist valleys and near the beach of the San Francisco downs, whence the roots, plants and cuttings may be transplanted to the beach for the purpose of erecting and maintaining the shore dune, and to any other portion of the drift, when desirable. Its growth from seed on the dry dunes is too slow during the first year to allow of its being raised in this way where it will be exposed to much drift."

Next in order of efficiency for sand reclamation purposes to the above plant, is the *Elymus arenarius* or *sea-lyme grass.* This is "a strong, rough, glaucose grass, which has been employed successfully in the maintenance of shore dunes in

France, under the name of "Courbet." It has been used to a great extent on the Holland downs and sea dikes, and although it is not as effectual a sand reclaimer as the "mat-grass," it is sometimes preferred to it for the reason that its straw is useful far many domestic purposes. It has been used in reclamation on the Baltic dunes of Prussia, where it is called the "sand-hair grass," and is preferred to the "mat-grass" for inland plantations. It has also been used very successfully in England. This plant thrives best when receiving fresh supplies of drift sand over it occasionally, but throwing out its shoots more nearly horizontally than the "mat grass;" does not grow through the sand and cover it as quickly and effectually as the latter. It may be raised from the seed on the higher portions of the dunes, but it is safer to propagate and use it in the manner prescribed for the "mat-grass." "

These two plants seem to flourish in the most arid and exposed situations without protection, and are therefore the best adapted to bind the particles of sand together, and prevent their drifting, which must be the first step in the process of reclamation. It may therefore be of interest to enquire how this work is done.

The writer is indebted to B. W. DeCourcy, C. E., for the following facts: "Rev. W. L. Rham, in 'Flemish Husbandry,' describes the improvement of poor, white sand. Trenching and leveling is the first operation, then the sowing of broom. In three years, he states, the land can be used to raise buckwheat, and from that on, by aid of manure, it becomes quite fair for raising rye, potatoes and some other crops. Mr. McLeod, of the Island of Harris, adopting another method, has brought into permanent useful pasture, a number of acres of useless drifting sand. He cut the plants of the *Arundo arenaria*, or bent grass, about two inches below the surface of the ground with a sharp spade. These are carried to the drifting sand and planted in holes eight or ten inches deep, and a handful is put in each of these holes, which are about one foot apart. Neither wind, rain or frost destroys this grass; it is excellent for wintering cattle on, and in three years, white or red clover will grow amongst it, provided it is well secured."

Mr. J. S. Polhemus, U. S. Asst. Engineer, in a letter to the writer, says: "In connection with the improvement of the entrance to Coos Bay, Oregon, and in fact as part of the project, we set several small plantations of the *Arundo arenaria*, or "Holland grass," chiefly as an experiment to see what plants were best adapted to grow on the black sand spit, and arrest the movement of the drifting sand under the action of the strong ocean breezes. We obtained the bunches of roots from the Golden Gate Park, San Francisco, Cal., where the grass has been very successfully used to reclaim a sandy waste and transform it into a beautiful spot by subsequent plantings of trees, shrubs, etc. We planted about six acres, by dividing the roots up into bunches about as thick as your wrist, and setting them four feet apart each way, and about fourteen inches deep in the sand. They were planted in early spring (April 1st), about three or four years ago, and the grass, although in a very exposed place, has grown and flourished and spread. It is the only thing we have been able to make grow, although we have tried many other plants. We never tried to sow the seed. I believe it is used in Holland and Denmark to reclaim the sand dunes along the North Sea. I think the grass would thrive in the climate of the Great Lakes, and be the best thing you could first plant."

The holding of the drifting sand, which is the object of the use of these plants, may also be accomplished by covering the surface with rows of boughs or brush. In France, these rows are laid "with the big ends of the branches toward the sea, and the twigs of the following row covering the big ends of the row previously laid on the ground, The arrangement of the boughs is therefore similar to that of roof tiles. The workmen lift big shovelfuls of sand taken from the portion upon which the cover is not yet laid, and put them upon the spread twigs. These shovelfuls are about two feet apart, measured from their centers, and suffice to hold the covers in place. The gang thus works backward." The drifting of the sand may also be arrested by the use of the palisades or fascines, as already described, but the effect of either of these methods is only temporary.

In the Golden Gate Park, the temporary stoppage of the drifting of the sand was sometimes successfully effected by sowing common barley broadcast. It sprouted from the seed on the fifth day after sowing, and attained a height sufficient to hold the drift on the twelfth day, and thus protect the slower growing plants whose seeds were sown at the same time. Mr. Hall thinks that possibly, buckwheat and chicory would answer this temporary purpose equally well.

After the drifting of the sand has been checked by either of these means, the process of clothing the dunes with permanent vegetation can commence. In the Golden Gate Park, this permanent vegetation is first prepared for by sowing with the barley, the seeds of two species of the Lupine family (*Lupinus arboreus* and *Lupinus albifrous*). "The yellow lupine of that climate is a hardy, perennial, half-shrubby plant, attaining a height of four or five feet, and covering an area equivalent to that of a circle six to eight feet in diameter. It lives to be three or four years old, bearing seeds abundantly after the first year. The blue lupine is a much smaller plant, seldom attaining more than half the dimensions above mentioned. It dies at the end of its second or third year, having produced but few seeds." These being short lived plants, answer only a temporary purpose and must be replaced by other plants. These are usually various species of pine. Mr. R. P. Hammond, Jr., Chairman of the Commissioners of the Golden Gate Park, thus describes the whole process of the reclamation of the sand dunes in that park. "All strong growing grasses with creeping or pointed roots are good for holding the sand. The best variety is the one planted here, viz., the Holland grass, *Arundo arenaria*. The best way to plant it is to plow the roots in, say in every third furrow drop in the roots, about two feet apart, covering them with the plow. Then plow another three furrows and drop in another row of roots, and so on. When the sand drifts are too steep for the plow, or where there are other plants growing in patches, the way they do is to dig pits, say about twelve inches deep and the width of a spade. In the bottom of the pit, drop a few of the roots, refill the hole and press the sand down firmly with

the feet. Dig the pits about three feet apart. After the grass is planted, sow the ground thickly with lupine seeds, covering the seeds with a hand rake. The following year plant the whole about four feet apart with some hardy variety of pine."

Mr. Robert J. Kerk, U. S. Consul at Copenhagen, thus describes the methods employed on the west coast of Jutland: "The plan generally followed in Denmark is to plant a belt of young trees (*Pinus montana or Pinus alba*), and then sow the sands, both in front and behind this belt, with the grass seeds known as *Arundo arenaria* or *Elymus arenarius*, using about 60 pounds per acre. Young trees can be had at a cost of about $2 per thousand. The seed is generally ready for shipping in the month of October, and costs about twenty cents per pound, bags not included. The trees should be planted and the seed sown in the fall or early spring. The *Elymus arenarius* seems to be more in demand for this purpose, as I am informed at the depot for seeds in Copenhagen. Another first-rate grass for shifting sands is the *Lattyrus maritimus*, which, besides fastening the soil, affords a nourishing and succulent food for cattle. This plant will also grow on poor and sandy soil situated far from the sea. It costs 40 cents per pound. Orders for these seeds should be placed not later than August, as they are not kept on hand in large quantities, and time must be given to procure them. They can be had from Markfrokontoret Nysola bodgade, No. 7, Copenhagen."

Mr. Vandeheyde, Consul-General of Belgium, says, in relation to the same work: "The only material employed are the *Pinus montana*, which is used in great quantities, and the *Pinus alba*. One makes use of the *Pinus Montana* in the dryest places, i. e. on the west and south sides of the hills, and in the parts covered with heath; the *Pinus Alba* is planted where the soil is sufficiently damp without being marshy. With these exceptions, there are not used on the dunes of Jutland any of the numerous species tried by us. The *Pinus austriaca*, which they have tried to acclimate, could not survive, and experience has, it seems, sufficiently demonstrated that no other material is known which will last long enough

here, because the young plant must not only be able to live in this arid soil, but it must also be able to grow there in a normal manner. The necessity of raising these young plants in the soil which is finally destined for them is one of the first conditions of success in the cultivation of woods, and it was thus that they proceeded from the very start."

L'Echo Ostende for October 15, 1893, says of the work in Belgium: "In the damp places, advantageously situated, there have been set out leaf-bearing plants (white areleas, black and white poplars, Canada poplars, etc.), and in general plants capable of spreading in a light soil. On the parts raised, but situated back of the sand hills, there have been set out *Pinus sylvestris, austriaca, Corsica*, etc. They have in the same manner made trials of several species of Sapins. Up to the present time these plants have been furnished in great part by the nurserymen in the environs of Bruges, or from the Province d'Anvers. Experience, however, has demonstrated that they must have the nurseries in the sand-dunes themselves. These nurseries have the advantages of furnishing acclimated plants and of being cheap, and they remove the causes of deterioration to which the plants are exposed by reason of the long transportation which they must undergo from the nurseries in the interior of the country to the sand-dunes themselves."

Mr. Hall says: "Top-rooted plants, to be successfully employed in sand reclamation, must be propagated upon the downs themselves, from seed; their success depending upon the progress of the leading root, which penetrates far into the sand before the top much more than shows itself. For this reason, also, all plants which succeed upon loose sands develop very slowly at first, while they are becoming well rooted, which fact had been the cause of the failure of early attempts at reclamation in Europe, the young plants being overwhelmed by the drift before they were large enough to hold the sands; and to prevent this was the object of the protective measures, which were afterward adopted."

Mr. Hall gives the following list of trees and shrubs which have been used with more or less success:

Maratime Pine (*Pinus maritimus*), sometimes called the

French Pine or Seaside Pine. This is the tree so extensively and successfully used in reclaiming sand downs in France. It is grown from seed on the sands. The young plants develop very slowly for the first two years; they then grow faster each succeeding season, and attain, upon the French coast downs, a height of twelve feet when six years old, twenty-five feet when ten years old, and a maximum elevation of ninety feet.

The seedling plants must be protected from drifting sands and the heat of the sun, and the sand above them kept moist by being shaded by brushwood or growth of some vegetation. This pine is adapted to cultivation upon the greater part of the San Francisco downs, including the highest and most arid portions. The seed should be sown in wide rows or belts through the lupine plantation when these latter plants are one year old, and the portion thus sown in pine should be covered by the lupine bushes which shall have been removed from them.

Cluster Pine (*Pinus Pinaster.*)—This tree is a native of the sandy shores of the Mediterranean, where it is a natural reclaimer of drifting downs. It is frequently confounded with the Maritime Pine, and good authorities differ upon the subject. It is cultivated upon the downs of France and other portions of Southern Europe, where its treatment, rate of development, and growth are very much the same as those of the Maritime Pine, but it does not attain so great a height.

Mr. DeCourcy says that "the plantations of these trees, called 'pegnadas,' constitute the principal riches of the inhabitants, who are almost entirely supported by the preparation of tar and resin from the pinaster trees raised in what were formerly useless drifting sand dunes."

Scotch Fir (*Pinus Sylvestris.*)—This is cultivated successfully upon the Prussian and other northern sand-dunes from seed, and also by setting out young trees. Better adapted to a cold climate than either *Pinus Maritimus* or *Pinaster*. Although a native of northern latitudes and grown principally in moist climates, it has been successfully introduced upon the driest sandy wastes of Australia, and is highly recommended for planting in sand downs in this country.

Larch (*Pinus Larix.*)—Recently used most successfully upon European downs, particularly in reclaiming those of France and Prussia.

Tamarisk (*Tamarix.*)—A family of beautiful small trees and shrubs, of which the French species, (*T. Gallica*), and the German, (*T. Germanica*), have been extensively used in sand down plantations and on sea-side exposures in the southern part of Europe and England. These plants stand the sea winds and salt-water air better than any other shrub or tree. They are readily propagated from cuttings upon the moist places in the downs themselves. The Arabian Tamarisk, (*T. Orientalis*), is found growing in the sands of the desert where no other vegetation exists, and the African variety, which is but a shrub six or seven feet high, is a native of the sandy shores of the Mediterranean.

Japan Varnish Tree (*Ailantus Glandulose.*)—A tree of most rapid growth in sand. It has but recently come into notice for purposes of reclamation in Europe, and proven itself one of the best for the purpose.

Sea-Side Willow (*Salix Argentea.*)—Much used in the construction of shore dunes in France.

Sand Willow (*Salix Arenarea.*)—One of the best trees for sand reclamation where much moisture exists. It does not suffer much from being nearly covered with drifting sand, but throws out new roots from every joint covered, and seemingly thrives the better from being in the drift. This tree has been used to a great extent upon sand downs throughout Europe.

Sand Stay (*Lapidospermum Lævigatum.*)—This shrub or small tree is the most effectual of all for arresting the progress of drifting sands in Australia. It may be raised from seeds upon the sand down itself like the pine.

Sword Ledge (*Lepidospermum Gladiatum*) and *Coast Sheoak*, (*Casnarinag Nadrivalvis*), are recommended as two of the most important plants for binding sea sand in Australia.

Common Broom (*Spartium Scoparium.*)—A late, handsome bush, bearing a profusion of yellow flowers, which grows readily from seed on sand downs. It was one of the first plants used in France in the work of reclamation, for which purpose it

occupies a position in the front rank of the shrubs which have been tried. The broom should take the place of the lupine when the latter begins to die, at the end of the third year. It attains the height of five feet on the French downs in four years.

Spanish Brcom (*Spartium Monosperum.*)—A beautiful large shrub, with sweet-scented, snow-white flowers, used successfully in Southern Europe to reclaim drift sands.

Common Furz (*Ulex Europœsus*), called by the French "prickly bromm," is a low-growing, coarse shrub, one of the first and most successful sand reclaimers used in France, but otherwise not desirable.

Some of the above mentioned plants may possibly require sea air for their successful cultivation, and would therefore not be available in Michigan, but the writer sees no reason why our own White and Norway Pines and some of the species of oaks and poplars which are found upon our sandy soils could not well be substituted for many of them, and possibly in time some valuable fruit trees.

There are also some grasses mentioned by Mr. Hall as more or less valuable for secondary reclamation purposes. Among these may be named:

Bent (*Grass Agrostis*), of which two varieties, the "common" (*A. Vulgaris*) and the "*Fiorene*" (*A. Stolonfiera*), are adapted to cultivation on very loose, sandy soils. They each possess the characteristic of spreading over a great extent of surface by means of their long runners, which root afresh at the joints, and interweaving with each other, form a carpet over the ground, which makes them useful on light soils. They do not stand being covered by drift, and hence are not adapted to the primary purposes of reclamation. They have been used successfully upon such works in England and Ireland, where showers of rain fall at short intervals, but have not received any attention as retainers on the continent of Europe.

Couch Grass (*Triticum.*)—There are two varieties of this grass adapted to sandy soils, the "common grass" (*Triticum repens*) and the "Sand Couch grass" (*Triticum janceum*), of which the latter has been used to some extent on works of

reclamation in Europe. Their habit is much like that of the "bent grass," and their long, white stalks are known to extend under the surface of loose soils for many feet.

Several members of the Lupine family, *Lupinus albus* particularly, have been extensively grown in Germany and France, where their tops when young are used for cattle fodder, and their seed fed to poultry. They have also been cultivated on poor, sandy soils to be turned under as green manure, but never before used for the purpose of reclaiming drifting sea sands.

It is highly probable that among our native Michigan grasses some varieties might be selected which would prove valuable for this purpose.

Mr. Hall states that the cost of sowing and maintaining the young forest of the French downs, exclusive of the works of protection at the beach, was about $13.50 per acre during the first years of reclamation. Of late years, owing to the advance in price of good seed and labor, the cost has been about $20 per acre. The cost of planting the grass upon the beach was about $11 per acre, and is now estimated at $14 per acre. The cost of reclamation by the use of grasses in Denmark has ranged from $10 to $15 per acre; and in Holland the expenses has been somewhat less for the plantations.

It is estimated that the cost of reclamation of the San Francisco downs with lupine will be less than $20 per acre, that the subsequent sowing and protection of the seeds will cost $25 per acre, and that the cultivation of the principal grasses will cost from seed $15 per acre, or by transplanting $35 per acre.

It will be observed that this estimate of cost applies to the case of lands which are entirely covered by drifting sands and are exposed to the full fury of the ocean storms and to constant accessions of great quantities of fresh sand thrown up by the waves, and that it is supposed to be sufficient to fit them for the purposes of an ornamental and attractive park. It is, of course, much greater than would be required for the ordinary reclamation of our Michigan dunes, where the surface is usually only partially broken, and all that is needed is the arresting of

the drift and the re-clothing of the surface with sufficient vegetation to hold it down.

The cost of erecting and maintaining the protective shore dunes by palisades and covering them with suitable grasses has ranged in France, Denmark and Prussia from 30 to 75 cents per lineal foot. In Michigan the cost would probably be greater than this wherever these protective dunes are necessary, but in a great majority of cases this would not be the case.

For any further information consult Appendix II of the Report of the Chief of Engineers, U. S. A., for 1890, and U. S. Consular Reports for September, 1895.

DISTINCTIVE FEATURES AND ADVANTAGES OF AMERICAN BRIDGE PRACTICE.

BY EDWARD BARRINGTON.

It is not the purpose of this paper to enter into the minutiæ of a subject so vast, upon which volumes have already been written and volumes more might still be written, but simply to pass in review the characteristic features of that practice, which, dating from 1833, when August Canfield took out the first patent for an iron truss bridge, and continuing down to the present day has given to American bridge building operations a new significance.

American bridge practice in its generic sense and world-wide significance dates from 1851, and really all that is valuable, all that is remarkable or worthy of discussion, is embraced in the experience and achievements of the past forty-four years. Back of that we find pretty much the dead level of mediocrity, a general, almost universal, employment of "rule of thumb" methods. The application of scientific principles and methods was extremely rare.

So much has been written upon the important subject of bridges that, perhaps, it might be considered as well nigh exhausted, were it not that there is no end to human ingenuity.

It is, therefore, with feelings of diffidence the author ventures to present a few remarks which he has somewhat hastily committed to paper, trusting that the practice in this line of our profession may interest some of the members of the Michgan Engineers' Society.

Some of the matter presented, such as the long list of comparatively obscure bridges, may prove wearisome, and a more elaborate description of famous bridges of recent construction would no doubt be more interesting, but the author

trusts that allowances will be made, when it is remembered that this is the contribution of a busy man who takes the liberty of laying before the Society information which has been hastily collected and put together, without garnishment of any kind.

It is needless to say that he does not claim originality for most of the matter contained in this paper. In its compilation he has liberally culled from more or less recent productions of such able authorities on bridge construction as George S. Morison, Theodore Cooper, A. F. Robinson, and others of prominence too numerous to mention.

The author regrets that there is not more reference made to the practical side of the subject, and that he permitted himself to dwell so largely upon the historical; however, he trusts some future opportunity will present itself, when it will be possible to enter upon the former branch of this very interesting professional study.

The practice here, now, tends to great simplicity of design, and in this, we believe, America excels all other nations.

It has frequently been remarked that of the many bridges which cross the Manchester Ship Canal, all built at once, there are no two alike. This must have had the effect of greatly increasing the engineering work and expense, and led to much unnecessary complication.

A cursory glance at the development of the art of bridge construction reveals a series of interesting facts:

First—That masonry arch bridges, from their simplicity, elegance, permanence, and strength, have in all ages been the most favored forms of construction for highways, and that the use of iron and steel has in no way changed this popular favor, except when the employment of these materials is either favorable to economy or to the introduction of larger spans. For railway bridges, other considerations favor the use of iron and steel.

Second—The introduction of cast-iron arches, though favorable to architectural elegance of design, has not resulted in any permanent useful developments.

Third—Timber bridges have in all ages been regarded as

temporary structures, which were to be replaced sooner or later by others more permanent in character.

Fourth—The springing up and immense development of the railway systems of the world within the last sixty-five years, and the concurrent progress made in the metallurgy of iron and steel, have given rise to entirely new problems in bridge-building and to a new branch of the engineering profession.

Fifth—The demands of railway traffic for direct lines which must surmount every obstacle regardless of cost, either by tunnels or bridges, the heavy weights transported, and the great speed of trains required, have directed, for a time, public interest from the highways, formerly, in the time of the old stage-coach, the only subject of consideration.

Viewed as intellectual and mechanical achievements, the bridges of modern times may now be classed with the steamships, locomotives, and pumping engines, which could not have been suggested a hundred years ago by the most vivid imaginations.

They are triumphs of science rather than art, and as such we would, perhaps, be content to look at them; deriving our interest from cold, impassioned reflection upon the thought, the genius, and the skill required to produce them, rather than from any such pleasing æsthetic emotions as arise when we look upon some of the works of the older bridge designers.

The construction of a line of land travel, of course, involves numerous bridges, rude and cheap in primitive times, but exhibiting elements of a more permanent character and more pleasing architectural features as a country advances in wealth, education, and civilization. There are few structures which more truly indicate intellectual cultivation and general prosperity than the bridges found along the lines of intercommunication more even than the roads themselves. It is unfortunate that the necessities of railway traffic have caused the introduction of forms of construction in iron here and there which mar delightful landscapes, and which contain no lines of grace perceptible to anyone except the engineer, who alone knows how much intellectual labor these uncouth skeletons and monsters have cost.

At present we may place bridges in four classes, as follows:

1. Beam or girder bridges.
2. Framed truss bridges.
3. Arch bridges.
4. Suspension bridges.

The framed truss is generally used for railway bridges, as it is economical, having the maximum of strength with the minimum amount of material. The I-bar, or flanged girder, is one of the most generally used forms of construction for bridges of short spans. Next in order comes the framed truss or framed girder bridge, the whole foundation of which is based on a triangle, which is the only figure the form of which cannot be changed without changing the length of one of the sides; and thus any truss to be perfectly braced and able to withstand any stresses that come upon it, must be framed so as to be divided into a series of triangles.

The simplest form of framed truss is the king post truss. The next is the queen post truss. Either of these trusses can be inverted so that the truss comes below the floor; the only difference that it makes is in the character of the strain that comes upon the different members of the truss. The vertical member of the upright trust is in tension, but when the truss is inverted it is in compression. The braces become ties, and the floor stringers are in compression. When it is desired to make the floor come upon the top of the truss, then the bottom chord or tie-rod can be omitted entirely, and the horizontal thrust taken by means of masonry abutments. There the weight comes directly down from the top of the bracing, and the lower end of the braces are held in place by the masonry abutments. From some combination of these trusses any form of bridge can be constructed. All bridges are composed of two or more trusses, which can be connected at the top and bottom. In the pony truss the only distinctive feature is that the trusses are not deep enough to allow of their being fastened together across the top, when the trains run upon the bottom chords, and they can only be used for short spans, and it is difficult to brace them so as to keep them in a true vertical plane. When pony trusses are used as deck bridges, they can be

braced so as to form very firm bridges; practically they are simply box girders.

The top and bottom members of each truss are called the chords, which are usually parallel to each other. In some types of truss bridges there are no bottom chords, as, for example, the Fink truss. For short spans it is a most convenient and economical method of construction and has been much used. In long spans the bottom chord is put in to add stiffness and stability. In the Bollman truss no bottom chords are necessary, the distinctive characteristic being that the tension members run directly from the lower end of each vertical compression member. In this respect they differ from the Fink truss. Theoretically this is the simplest bridge that can be constructed; but when the spans become of any great length, the tie-rods become unmanageable. In railway bridges the trusses are all some combination of the king post truss, either upright or inverted. The most common is known as the Howe truss. In this the braces are diagonal, and the tension members vertical. Although not an economical truss, it is much used owing to its simplicity of construction. A very large "factor of safety" has to be used in all Howe trusses owing to the uncertain character of the wood; this is never less than five and frequently ten. Of course the Howe truss can be used either as a deck or through bridge. Many remarkable examples of this type of bridge have been constructed in the United States, designed by ordinary carpenters, who had received not a particle of technical education, which have been very durable.

As iron decreased in price, a very economical type of bridge came into vogue, in which the lower chord was made of iron in place of wood; it was called a "combination bridge," that is of iron and wood. The next form was the Pratt truss, the distinctive feature of which is that the compression members are vertical, while the tension members are diagonal or inclined. In this type the amount of iron is increased and wood decreased, supposing the tension members to be of iron and the compression members of wood. In a short time the wooden posts were removed and iron posts substituted, and then we had an entire iron bridge, in which compression mem-

bers are vertical and tension members inclined. This is the "typical American railway bridge." The next form of truss was the Warren triangular girder, in which each of the pieces connecting upper and lower chords act both as ties and braces. The only advantage claimed for this bridge is simplicity and fewer number of parts than any other form of bridge truss. But, by reducing the number of parts, the sizes were increased, and thus much of the advantage was lost. When this type of bridge is used as a deck bridge and a floor system is laid on top of the chord, vertical posts are necessary, but for a through bridge they are not required. Where good timber of large size can be procured, this is as economical and convenient a form of truss bridge as can be built. The lower chord must be made of iron, but the tie braces and top chord of wood. A complicated method of fastening the tie braces is necessary, as they have to resist both tension and compression. A great advantage in using this kind of truss is the ease with which any piece can be removed and replaced by a new piece without suspending traffic. The Post bridge is the last type that has been used to any great extent in this country. Its characteristic feature is that the compression members are inclined at what is claimed to be the most economical angle, considering the amount of strength obtained for the amount of material used. They are so inclined as to cross one panel of the bridge, while the tie-rods, running at an angle with the braces, cross two panels. This is the only advantage, and it is more than counterbalanced by some of the difficulties encountered in the actual construction, and it is doubtful if this type is really more economical than the Pratt.

The author will not elaborate on the bowstring girder, masonry-arch, or suspension class of bridges at present, as he feels sure all are more or less familiar with their peculiarities of construction. He will merely add, that there are inherent defects in the suspension type which render it inapplicable to rapidly moving heavy loads, which will always be a sort of bar to its general use. For excessively long spans it has no equal for slow moving loads.

The last type he will dwell upon is the cantilever, in which

the variations are almost infinite, although the principles are the same in all. In the bridge that crosses the St. John River, at St. John, New Brunswick, the upright trusses are used to support a framed truss in the center; whilst in the bridge across the Hudson River, at Poughkeepsie, the trusses are inverted, the ties becoming braces, the floor comes upon the top, the shore ends being firmly anchored, and the suspended span held in place. Where great length and increased strength is desired, a combination of the two is resorted to as in the case of the Forth bridge. By using the cantilever, we gain the following advantages for long span bridges: (1.) As a substitute for the suspension bridge it is, up to a certain length of span, less expensive, and it can be given great rigidity and stability. (2.) As a substitute for the framed truss it requires no false work for its erection. And lastly, it is possible to transfer the weight of the superstructure exactly to the centre of the pier instead of placing it near the edge of the pier, as must be done with separate spans. Many claim that cantilevers are a modern invention; such is not really the case, as there now exists in Japan as perfect and scientific a cantilever bridge as any either here or in Europe, which was built by order of the Mikado 250 years ago.

In timber bridges America has taken the lead of all other countries; the only structures in Europe comparable with them are the Schaffhausen and the Wittengen bridges across the Rhine. A famous bridge of timber called the "Colossus of Fairmount," was erected over the Schuylkill, at Philadelphia, by Louis Wernwag, towards the close of the last century. It had the form of a very flat arch, 340 feet span. Its slender, graceful appearance was much admired, Fanny Kemble comparing it to a "scarf rounded by the wind, and flung across the river." It was destroyed by fire in 1838.

Timothy Palmer built several notable bridges, one of which crossed the Schuylkill, at Philadelphia. The construction was a combination of king posts and bracing with the arch. Among notable designers of timber bridges during the early part of this century appear the names of Burr, Towne, Long, and Howe, the two latter having followed Towne, and produced

modifications of his truss, to which their names have since become attached. Towne's truss was such a remarkable and important improvement—the application, in fact, of a new mechanical principle in bridge building—that it was immediately extensively copied; the most important example being the bridge erected across the James River, at Richmond, built by Moncure Robinson. The length of this bridge was 2,900 feet. It was supported by eighteen granite piers, at distances apart, varying from 130 to 150 feet, and cost $100,000, or about $3,500 per lineal foot.

Other bridges on the same principle were built, one across the Susquehanna, 2,200 feet long, with one span of 220 feet; others erected at Nashua, N. H., Newburyport, Springfield, Northampton, Philadelphia, Trenton, near New York, another near Troy, and many others in the Southern and Middle States. These bridges have nearly all disappeared, wrought iron having taken the place of timber, while the principle of Towne is still preserved in the new material of construction.

Some forty odd years ago an English writer remarked that American timber bridges "looked like coffins for sea serpents," because they were boxed in to preserve them from decay and snow-drifts, although giving their design pre-eminence. Now, the coffin is removed, and the skeleton, transmuted into iron, is fully exposed to view. The only wrought iron bridge in the United States which has elicited from travelers expressions of delight, owing to its architectural elegance of design, is the Girard avenue bridge in Philadelphia, which was built under certainly favorable circumstances.

As early as 1787 the need of a material for long span bridges more suitable than wood was considered necessary. In 1803 Thomas Paine advocated the construction of iron bridges. The only iron bridge then existing was near Coalbrook Dale over the Severn. No further consideration seems to have been given the subject until 1830, when Long and Towne—who were experts in the construction of wooden bridges, as already mentioned—both suggested that their bridges could be made in iron and wood. In 1833 August Canfield took out the first patent for an iron truss bridge, and

Mr. Earl Trumbull in 1840 built the first iron truss bridge over the Erie Canal at Frankford, N. Y. In the same year Squire Whipple, built his first iron bridge. In 1846–47 James Millholland built a boiler plate tubular girder fifty-five feet long. In 1846 Frederick Harbach patented an iron Howe truss. About 1847–50 Nathaniel Rider built a number of bridges of iron; the failure of one of these bridges in 1850, following the failure in England of a bridge over the river Dee, influenced the officials of the Erie Railway to direct all iron bridges to be removed and replaced with wooden structures.

About 1851, Mr. B. H. Latrobe, chief engineer of the Baltimore and Ohio Railway, gave the first impulse to the general adoption of iron bridges. He had previously much experience in the construction of wooden bridges in which iron was extensively used. In 1852 a Bollman truss, 124 foot span, was built at Harper's Ferry. In 1851–52 three spans of 205 feet each on the Fink plan were built over the Monongahela River. In 1852–3 Squire Whipple built a double-intersection Pratt truss iron bridge, of 146 feet clear span, near Troy, N. Y., which continued in use until 1883, although it was only proportioned for a rolling load of one ton per lineal foot. From 1851–61 the Pennsylvania Railway built many iron bridges from 65–110 feet span.

In 1857 F. C. Lowthrop built his first railway bridge. It consisted of eleven spans, total length 1,122 feet, supported on iron trestle towers.

In 1858–59, J. W. Murphy built a Whipple bridge, of 165 feet span, at Philipsburg, N. J., which was the first truss bridge pin-connected throughout. In 1861 J. H. Linville built a bridge over the Schuylkill River, in which wide forged eye-bars and posts, formed of wrought-iron sections, were used for the first time. In 1863 J. W. Murphy built a bridge at Mauch Chunk, in which he used wrought-iron for both the posts and top chord sections. This was the first American truss bridge in which the tension and compression members were of wrought iron. He used, however, cast-iron joint blocks and pedestals. In 1865 S. S. Post built the first Post truss iron bridge at Washingtonville. Between 1865 and 1880 many bridges of this style

were built. In 1859 Howard Carroll began building riveted lattice bridges, mostly of short spans of 40-90 feet. The excellence of Mr. Carroll's work, gave the preference to this class of bridge on many railway systems. In 1874 Mr. Charles Hilton built a bridge of this style across the Connecticut River, having seven spans of 180 feet each. The author neglected to mention that Mr. Felician Slataper built a bridge over the Allegheny River in 1864, having five riveted lattice spans of 178 feet each, and in 1865–66 Fairbairn & Co., of England, built an iron lattice bridge over the Connecticut River, from designs by James Laurie, the longest span being 177.25 feet.

Long span bridges date from 1863–64, when the first bridge was built over the Ohio River, at Steubenville, by J. H. Linville. The channel span was 320 feet long and twenty eight feet deep. This was followed in 1868–70 with one over the same river at Louisville, built by Fink, with two main spans of 360 and 390 feet. In 1870 Linville built a bridge over the Ohio River at Parkersburg, with channel spans of 340 feet, and in 1872 he built the Cincinnati bridge over the same river, with a channel span of 420 feet. During 1868–74 J. B. Eads built the St. Louis bridge across the Mississippi River, containing two arches of 502 feet and one clear span of 520 feet. In 1876 the Cincinnati Southern Railway bridge over the Ohio River was built from designs by Linville and specifications by Bouscaren. The channel span was 519 feet, the longest truss span built up to that date. The channel span of the Henderson bridge, and of the Ohio River bridge of the Kentucky Central Railway, at Cincinnati, are 522 feet and 550 feet respectively. There are now about seven miles of American railway bridges with spans from 300-400 feet, nearly five miles with spans from 400-500 feet, and about 3.5 miles with spans exceeding 500 feet. estimated as single track bridges, all exclusive of wire suspension bridges. The first iron cantilever bridge of importance was the Kentucky River bridge, designed and built by C. Shaler-Smith in 1876–77. It is 1,125 feet long, and consists of three equal spans of 375 feet. The second was the Minnehaha bridge over the Mississippi at St. Paul, built in 1879–80, and consisting of one centre span of 324 feet, and two shore spans

of 270 feet each. The third and fourth were the Niagara and Frazer River bridges, designed by C. C. Schneider, the first being completed in 1883, and the second in 1885. The St. John River cantilever was also built in 1885. Since that time many have been built, the one of greatest importance and magnitude being the Poughkeepsie, crossing the Hudson River near New York.

While on the subject of cantilever bridges, the author cannot well avoid referring to the Memphis Bridge across the Mississippi River, the first bridge built across that river below St. Louis. This bridge, by connecting ten lines of railroad, opens a way for traffic from the west and south-west to the Atlantic seaboard. It has the distinction of having the third longest truss span in the world. The Forth and the Sukkur (India) Bridges have longer spans. This span is 790 feet, and consists of two cantilever arms 169 feet 4.5 inches each and a central span of 451 feet 8 inches. On one side of this long span is another span of 221 feet, and on the other two spans of 621 feet each, one a continuous span, and the other a cantilever arm and simple truss. The bridge is 75 feet above high water, and 109 feet above low water.

The piers were sunk by the pneumatic process, the deepest one reaching 108 feet below water-surface. In only the east abutment of the St. Louis Bridge has the pneumatic process been used with a greater immersion, and then it was 109.7 feet. The bridge was finished April 24th, 1892, and formally tested May 12th, 1892. It ranks with the great bridges of the world.

The author would also mention, in passing, the erection of the highest bridge American engineers have yet built. The Pecos bridge has this distinction of height, and its height is exceeded by but one other in the world. It is 328 feet above the surface of the water of the stream, while the highest in the world, the Loa Viaduct, in Bolivia, is 336 feet and 6 inches high. The Kinzua Viaduct in Pennsylvania, the third highest, is 302 feet high. The Pecos River Viaduct is 2,180 feet long, consisting of 48 spans, mainly plate girders, alternately 35 and 65 feet long. The channel span is a cantilever 185 feet long. The substructure consists of masonry piers with steel trestle

towers. The highest tower is 321 feet high, 35 by 100 feet at bottom, and 35 by 60 feet at top. Mr. Geo. S. Morison was engineer of the Memphis Bridge, and Mr. Wm. F. Kendall engineer in charge of the Pecos River Viaduct.

The comparative economy of iron, combination and wooden bridges is as follows, according to the report of the Committee of the Association of Railway Superintendents of Bridges and Buildings. Assuming a span of 175 feet, and taking first cost and the saving within 20 years by using the cheaper structures, capitalized at 4 per cent., this Committee reaches this conclusion:—

Span of 175 feet.	Cost.	Saving in 20 Years over Iron.
Iron: with forged steel eye-bars	8,000 dols.	
Combination Iron with wood compression members	6,800 dols.	2,611 dols.
Howe Truss covered with Galvanized Iron	6,000 dols.	4,382 dols.

From this it appears that the net saving by building either a combination or a wooden bridge, compared with the cost of an iron structure, will not be enough to pay for rebuilding at the end of the natural life, at which time the iron bridge would still be in perfect condition. An iron bridge can be maintained 75 years, if kept painted and otherwise properly cared for, which, while a matter of opinion, seems to be justified by experience thus far gained. A wooden bridge is safe, a combination bridge is safer, and an iron bridge safest, cheapest, and best.

The author has refrained from more than alluding to the Brooklyn Suspension Bridge, as the work is of so stupendous a character as to require a whole discourse to itself. Probably the most interesting feature in connection therewith is the fact that Mr. Roebling, the famous engineer who supervised the construction of it, lost his sight from an accident in one of the caissons shortly after the commencement of the work, and completed that magnificent bridge (probably the finest in the world, taken as a whole) by dictation to his wife, a lady of great mathematical acquirements, who intelligently explained his designs to the assistant engineers as the operations progressed.

The present seems to be an era of big bridge building in both this and foreign countries. The bridge across the Mersey at Liverpool is to consist of 3 arched suspension spans of 1,150

feet, and 150 above high water, with railway tracks, roadway for vehicles, and sidewalks. It is proposed to bridge the Bosphorus at Constantinople by a structure 8,645 feet long. The Channel bridge between England and France, as at present proposed, will consist of 73 spans, alternately 1,300 and 1,625 feet in length, with a clear headway of 175 feet. Two have just been completed across the North Sea and Baltic Canal, with 150 feet spans, carrying railway tracks, roadway and footpaths. In this country the new East River Bridge at New York, as projected will have a span of 1,670 feet, a total length of 3,200 feet, a clearance of 140 feet, and will carry 4 railroad tracks. The North River bridge will have one span of 3,100 feet, and carry four railway tracks and a roadway and footpath at each side of the bridge.

The author will digress for a moment to mention the peculiar features of two bridges which run lengthwise of canyons in the Western States. The first is in the Apache canyon of the Rio Galisteo, on the main line of the New Mexico and Southern Pacific Railway. The centre line is on a 10-degree curve, and it is 14.5 inches off the centre line of the bridge at the ends and centre. The second case is in the Royal Gorge of the Arkansas River, and is known as the "Hanging Bridge." The great peculiarity is the suspension of one of the trusses from the intersections of pairs of inclined beams which rise from abutments against the rocks on opposite sides of the canyon to the point of intersection, where they abut against each other.

A curious bridge, found on the Canadian Pacific Railway, crosses a tremendous chasm, and the best way that could be seen of surmounting the difficulty was by resting the bridge on two trees which were growing in the abyss below. The tops of the trees reach the ground above, and the bridge rests upon them.

The characteristic difference which exists between American and English practice of bridge building, is in the methods used in joining together the different parts of the bridge—American bridges, as a class, being pin connected, which leaves the joints flexible; whilst English bridges have riveted connec-

tions, and each member acts simply as a part of a rigid, inflexible whole. It would occupy too much time to enter into the various causes which have led to these differences, suffice it to say that much ingenuity has been displayed by American engineers in the combination of triangles used in bridge designing, and in many cases this has led to absurdities. At present the whole tendency in American practice is to extend the use of riveted joints, and in English practice to extend that of the pin connections. Both are working in opposite directions, but from opposite sides, and therefore towards the same point. One great drawback to the use of the pin connections by English engineers, is the immense first cost of the plant necessary to do the work. Our bridges are usually designed and built by the same company, so that the designs, within certain limits, correspond to the available plant of the manufacturer, and expensive tools can be used over and over again.

In English practice, bridges are designed by individual engineers, and some firm has to build them in all their multiplicity of details to correspond with the designs. In riveted work, however, the tools required are the same within certain limits, regardless of the details of design. Pin-connected bridges are much more economical for large work than riveted ones; and this, taken in connection with the unrivalled facilities for doing the work, accounts for the fact that in the building of large bridges, American firms can underbid any others, and not in any way lower the character of the work done. A very important consideration is that pin-connected bridges can be erected in *one-twentieth* of the time required for the erection of English riveted bridges.

While the pin-connected bridge is especially the American type, our engineers have learned much from European practice. The promptness and fullness with which their works and practice have been given in current technical literature has been quickly taken advantage of by us. Another advantage has been the combination of designing, manufacturing and erecting quite intimately. Theorists and hobbyists have thus less weight here. Great uniformity exists in the styles of bridges adopted for various spans. Fifteen years ago a thousand

styles of bridge existed; while to-day there is a general approximation to certain broad types in style and detail, although no two bridges are exactly alike.

Plate girders are used for spans up to 65 feet usually, but some railway companies are using them up to 100 feet. These girders are completed at the shops. They give excellent satisfaction. Up to 65 feet they are cheaper than lattice girders; maintenance is less; security is far greater; they are cleaner; and faulty rivets make much less proportionate reduction in strength than in lattice girders.

A 182-foot plate girder swing bridge is now being built for the Washington and Chesapeake Beach Railway Company by the Youngstown Bridge Company. This will be the longest plate girder span ever erected in this country, and was designed by Mr. C. E. Fowler, Chief Engineer of the Bridge Company.

Riveted lattice girders have been quite generally used on all our railways for short spans and by some for all spans, still the preference remains for the plate girders. Lattice bridges have no merits which are not possessed by pin-connected types. They are usually limited to spans between the longest plate girders and minimum pin-connected spans; this limit is not fixed, the lower limit being determined by relative cost of plate and lattice girders, and ability of railroads to transport long plate girders, and the upper limit by the preference of the engineer. These limits are somewhere between 60 and 120 feet. One advantage of the riveted form over the pin-connected form for lower spans, is the additional stiffness of the connections and forms of members, each case determining the circumstances. Pin-connected bridges could be made equally stiff for the lower spans, and still attain perfection of fitting and lengths of parts peculiar to them, if the connections where reversal of stress occur were rigidly bolted and riveted together. Theorists might object to this, owing to secondary strains. These can be held in subjection if restrained within certain bounds. As long as friction exists, pin-connected bridges will not be free from them.

Lattice riveted bridges and double intersection trusses have not been more fully discussed, as their introduction

would only have the effect of obscuring the object of this paper.

A brief retrospect of the evolution of bridge construction suggests that, as regards form and proportion, the following mechanical principles have been found worthy to survive:—

1. The panel system, whereby the diagonal members were kept at economical angles, produced the trusses built by Palmer and Burr.

2. The principle of counterbracing these panels led to the trusses of Long and Howe.

3. The idea that diagonal compression members should be made as short as possible caused the Pratt and Whipple forms to arise.

4. The idea of varying the depth of the truss to render stresses as nearly uniform as possible brought the curved upper chord into use.

5. The methods of suspending alternate floor beams without the use of a double system of bracing, gave rise to the Baltimore truss; and lastly,

6. The combination of all these good qualities produced the form known as the bowstring or arched truss, whereby are gained, in addition, the advantages of that type, in making nearly uniform the stresses in both chords and web members. It is not intended to imply that this truss is one universally applicable with maximum economy, but merely that it appears to typify the best and most successful American practice, and renders it applicable to the longest simple spans.

The trial and rejection of many kinds is a necessary element of the progress of evolution, and in our present forms of trusses, are embodied the lessons taught by all preceding ages. At present, in a flourishing existence, as the result of this evolution, are found the Pratt, the Baltimore, and the curved bowstring trusses, the first being best adapted for short, the second for medium, and the last for long spans.

Extended investigation seems to show that under the most favorable circumstances iron bridges are not safe for a period of over 75 years; and under certain conditions their life is much shorter. The method of manufacture is of the *least* importance

in the estimate of durability. The effect of a more or less heavy traffic upon the fibre resistance in the materials of construction plays an important part, and the pounding under the train motion and the vibration due to rolling loads wear out the bridge.

With the exception of a few hundred spans, the longest of which are 260 feet lattice-bridges, the 7,645 spans of iron railway bridges of the United States over 100 feet, and aggregating 232 miles in length, are of pin-connected type. American engineers adhere to them, as their merits are strong and positive. Good bridge designs do not contain more than a single system of triangulation in their forms of trusses. Those now adopted are such as give the greatest concentration of parts, with long panels, and without theoretical or practical ambiguity of strain under a miscellaneous series of wheel loads.

Forms of members requiring cast-iron joint-boxes or other uses of this material are now obsolete. The Bollman, Fink, Lowthrop, Post, and double-intersection Whipple and Linville trusses have disappeared from practice here, and parallel chords and equal spans are generally used now; this gives a minimum number of parts, and leads to greatest economy and accuracy of manufacturing. For long spans the depth may be advantageously reduced at the end panels. The channel span of the Ohio River Bridge at Cincinnati is the longest pin-connected truss span in existence, being 545 feet from centre to centre of end pins, 84 feet deep at centre, and 60 feet deep at the end posts; panel lengths 27 feet 1.5 inches; trusses 30 feet apart, centre to centre. It carries a double-track railway between the trusses, and has on each side a wagon-way and foot-walk, 16 feet wide.

In summing up the essential characteristics of the *typical American railway bridge*, we find it is a skeleton structure, pin-connected at all principal articulations; so formed as to reduce all ambiguity of stress to a minimum; concentration of parts; facility of manufacture; perfection of lengths and fitting of all members; which reduces to a minimum all riveting and mechanical work in the field, and finally readiness with which the individual members can be assembled during erection.

The relative amount of bridges and trestles varies in different districts from 58 feet to 231 feet per mile of track. This last is excessive, as it includes the crossing of Lake Pontchartrain, near New Orleans, on a trestle 22 miles long. Omitting this, we would only have 162 feet per mile as the maximum. These variations are not entirely due to geographical location. They are affected by principles governing the original location of each road. The alignment and grade may have been sacrificed to the avoidance of bridges or trestles, or the contrary. Carefully prepared statistics show that there are 3,333 miles of bridges and trestles on our railways, or about 100 feet per mile of track on the average, which is distributed as follows:—

Trestles and Spans under 20 feet.	2,662 miles.	799,900 spans.
Spans..... from 20–50 "	132 "	19,985 "
Spans..... from 50–100 "	143 "	10,000 "
Spans..... from 100–150 "	209 "	8,800 "
Spans..... from 150–200 "	120 "	3,600 "
Spans..... over 200 "	63 "	1,265 "
Total,	3,333 "	843,590 "

The above includes all bridges of either wood or iron. The iron bridges are as follows:—

Iron Spans under 20 feet.	19 miles.	5,610 spans.
Spans from 20–50 "	94 "	14,190 "
Spans from 50–100 "	72 "	5,600 "
Spans from 100–150 "	102 "	4,200 "
Spans from 150–200 "	76 "	2,310 "
Spans..... over 200 "	54 "	1,045 "
Total,	417 "	33 045 "

The records for iron bridges under 300 feet spans are very incomplete; those over 300 feet are as follows:—

Spans..... over 500 feet.	3.5 miles.
Spans from 400–500 "	5.0 "
Spans from 300–400 "	7.0 "
Total,	15 5 "

Deducting the amount of wooden trestles which will probably be filled in embankment, and the bridges which will be maintained in wood, there remain about 1,100 miles to be gradually replaced with iron bridges and trestles; spans probably may be from 50 feet to 200 feet. This would make 1,517 miles of iron bridges for the 175,000 miles of railroad now in existence, of which only 417 miles are at present built. The substitution of iron for existing wooden bridges, of course, will be gradual, so there will be no dearth of employment for our

bridge building firms for some time to come. The lineal feet of highway bridges which will be required in the same time will be about five times that required for railway use only.

Distorted reports frequently appear in foreign publications relative to railway bridge failures in the United States, which engender false impressions and conclusions. It is hardly necessary to state that these reports are collated from newspapers and not from official returns, and are full of inaccuracies. The number of failures here, due to causes or forces which a bridge should be designed to meet or resist, is an exceedingly small one, considering that there are over 843,530 spans—of which over 33,000 are iron—on our railways, and when the circumstances under which they are mostly built is properly considered, and the rapid development of our railway system, together with the enormous increase in weight of our loads carried and weight of rolling stock, which is now met by much heavier structures than formerly. The demands for cheap railways, far in advance of settlements, compelled cheap and light structures originally. Not a single all-wrought-iron American railway bridge has failed under legitimate train service. Defective and inadequate structures of the past have taught us the relative merits of the various forms and proportions of the members and their details. Our knowledge has passed far beyond the study of stresses and tests of specimens, and we do not cover our ignorance under a so-called factor of safety. We have studied the working under excessive loadings, even up to rupture, of structures and details which had outlived their intended purpose or were improperly designed from the beginning. Without some failures there would be no evolution or the survival of the fittest.

BRIDGE BUILDING, PAST AND PRESENT.

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The science of bridge building, for such it has become, may be said to have had its origin and development in our country. Bridges were built in European countries in very early times, but the practice in America has been followed in a distinct line of its own. In the course of its development it has undergone such a complete evolution that to the better understanding of the position it has attained and now occupies, I will ask your indulgence while briefly tracing its course through this period of development.

From Theodore Cooper's paper on bridges the following historical information was principally obtained:

Bridge building in America had its beginning with the dawn of the new world. The pioneer was called upon to bridge small streams, and having limited resources, and no precedents, his ingenuity and skill were drawn upon and given full sway. The earliest bridges where single timbers were not sufficient to stretch from bank to bank, were short spans supported on piles, or, where piles could not be used, on timber cribs filled with stone. Where the conditions would not admit of structures of this kind, arch spans were usually adopted.

Among the early structures of note, was the so-called "Great Bridge," a pile structure built across the Charles River, between Old Cambridge and Brighton, in 1660. In 1786 a bridge 1,503 feet long was built over the Charles River at Boston, which was supported on seventy-five piers.

In 1810 a chain suspension bridge was built at Newburyport, Mass., of 244 feet span, center to center of towers, the chains being composed of links about two feet long, made of one inch square iron. The roadway was supported by two sets of chain cables, each cable composed of three chains.

In 1794 a bridge was built near Portsmouth, N. H., 2,362 feet long, in the center of which was an arch span of 244 feet 6 inches, and with a rise of only 27 feet 4 inches; quite a masterly piece of architecture.

In 1805 a bridge of three spans 163 feet clear was built over the Delaware River, at Easton, Pa. It was covered in from the weather and is still in use and in good condition.

Many bridges of considerable magnitude were built up to 1820, but were arched structures.

In 1820 Ethiel Town patented his lattice bridge, which was the first marked step toward bridges of the modern truss form. A great many of these were built up to spans of 220 feet, both for highway and railroad puposes, and some are still in existence. The absence of all bolts, straps, and rods, and simplicity of connecting together the parts, made this a cheap and popular structure.

The next step towards simplicity and concentration of parts was the Long Truss, in which iron did not necessarily enter. Many of these were built, but it did not become widely popular.

Each of these trusses were combined with arches oftentimes, for the longer spans. The next important advance in style of truss was made in 1840, when William Howe patented the truss which was the basis of the present Howe Truss bridge. In his truss the vertical members were in tension and made of iron rods, all the rest of the members being of wood.

In 1844 the Pratt Truss was patented. It differed from the Howe Truss in that the vertical members were in compression and made of wood and the inclined members were in tension and made of iron. This did not become as popular as the Howe Truss on account of the greater quantity of the, then, more expensive material, wrought iron, being required.

The development of wooden bridges was entirely empirical, the proportioning of them being determined either from the result of previous failure or from the study of models. An advance was shown, however, towards simplicity of form and construction, and in the matter of details.

The first iron truss bridge built is believed to be the one

erected over the Erie Canal, at Frankfort, N. Y., in 1840. The truss was a combination of the truss and suspension principle, and was formed of seven cast iron sections, about 11 feet long and 7 feet deep, bolted together, each section consisting of an upper chord, a pair of diagonal braces, and half of a hollow cylindrical post at each end, to the bottom of which were bolted wooden transverse floor beams. Two wrought iron suspension rods one and one-half inches round, were attached to the tops of the end posts, and sagging in a parabolic curve passed underneath the two central floor beams supporting them, and by means of lugs at proper elevations, were attached to the other posts.

In 1840 Squire Whipple built his first iron bridge, a bowstring truss, the compression members being cast iron and the tension members wrought iron. A good many of these were built with spans from 50 to 100 feet, and some up to 180 feet.

In 1846 Frederick Harbach patented an iron Howe truss. The top chord and braces consisting of cast iron hollow cylinders in pairs, and the lower chord and vertical rods of wrought iron. The lower chord being two cylinders of boiler iron riveted together as continuous tubes. The chords and braces were connected by cast iron saddles.

In 1847–50 a number of bridges were built for the New York and Harlem, Erie and other railroads, having parallel chords and multiple systems of vertical posts and diagonal ties. The compression members being cast iron, and the tension members flat bars of wrought iron. The members were bolted together and wedges inserted at top of each post to tighten up the systems.

The failure of one of these bridges on the Erie Railroad, in 1850, at about the same time as the failure of one in England over the River Dee, led the officials of the road to the belief that iron bridges were untrustworthy, and they directed that all the iron bridges on the road be removed and replaced by wooden ones.

The first impulse to the general adoption of iron for railroad bridges was given by Benjamin H. Latrobe, Chief Engineer of the B. & O. Railroad, when he decided to use iron in

all the new bridges upon an extension from Cumberland to Wheeling.

From 1851 on, a good many bridges were built on the Bollman and Fink plan, using both cast and wrought iron in them.

In 1852 Squire Whipple built a double intersection Pratt Truss on the Rensselaer and Saratoga Railroad, near Troy, N. Y., of 146 feet clear span, which was proportioned for a rolling load of only one ton per lineal foot.

In 1858-59 a Whipple Murphy bridge of 165 feet clear span was built at Phillipsburg, N. J., which was the first span to be pin connected throughout.

In 1861 Mr. J. H. Linville built a bridge for the Pennsylvania Railroad, in which was used for the first time wide-forged eye bars and wrought iron posts.

In 1863 John W. Murphy built a bridge for the Lehigh Valley Railroad at Mauch Chunk, in which he used wrought iron for both posts and top chord sections. This was probably the first American bridge in which all the tension and compression members were of wrought iron. In this were used, however, cast iron joint blocks and pedestals.

In 1865, S. S. Post built his first bridge, known as the Post Truss, for the Erie Railroad. A large number of these bridges were built up to 1880, due, in part, to their apparent stiffness.

In 1859, Mr. Howard Carroll commenced building riveted lattice bridges for the N. Y. C. Railroad, in spans from 40 to 90 feet, and being well proportioned as to strength of parts and details of connection, soon took the preference on the Central and neighboring systems. The spans were afterward extended up to 180 feet.

The era of long span bridges dates from 1863-4, at which time a span of 320 feet was built over the Ohio River at Steubenville. This was proportioned for a load of 3,000 pounds per lineal foot of track, and was made of cast and wrought iron.

In 1872, the Newport and Cincinnati bridge was built, one span being 420 feet.

In 1868-74, James B. Eads built the bridge at St. Louis over the Mississippi River, consisting of two arches of 502 and 520 feet clear span each.

In 1876, the Cincinnati Southern bridge over the Ohio was built, having a channel span of 519 feet, the longest truss span ever built to that date.

The channel span of the Kentucky Central Railway, at Cincinnati, 550 feet, was the longest independent truss bridge up to 1889.

The first important iron cantilever bridge was the Kentucky River bridge, built by C. Shaler Smith in 1876-77, consisting of three spans of 375 feet each. Next was the Minnehaha bridge over the Mississippi, at St. Paul, built in 1879-80. Third was the Niagara Cantilever on the M. C. Railroad, designed by C. C. Schneider, and built in 1883. This bridge, which has been under my personal inspection for the last four years, is a double track structure, consisting of a single span 495 feet centre to centre of towers, and it is approximately 250 feet from base of rail to the water in gorge below. We have lately had to adopt measures to prevent a rusting of the iron caused by brine dripping on it from refrigerator cars. A train of these cars stand upon the bridge while the Custom Officers are making their inspection, and in warm weather considerable brine drips from them. Paint proved to be of little avail in protecting the iron, so we were obliged to adopt means to keep the brine from coming in contact with the iron at all. This was done by filling in between the ties with a petroleum product called Byerlyte, which drained the brine towards the center of the bridge, where it was collected in gutters and carried off.

The cantilever of largest magnitude is the Poughkeepsie bridge, built in 1888.

The advantages of the cantilever are the ease and economy of erection of long spans over deep gorges or rivers, where the waterway cannot be obstructed.

The combination bridge, a type holding a place between the wooden bridge and the all iron, was used a good deal in the south and west, being cheaper than the wooden bridge. Its adoption was governed chiefly by the financial ability and policy of the corporation for whom they were built.

The iron viaduct, a type of bridge holding an important

place among bridge structures, had its origin about 1868 in the construction of the Bullock Pen Viaduct, on the Cincinnati and Louisville Short line—a structure 470 feet long and 60 feet high. The first step toward the use of iron in viaducts was in 1851, when iron rods were used for longitudinal bracing in wooden trestles to hold the bents together. Next came the gradual use of cast iron for all compression parts until 1868, when we had the all iron structure mentioned above. The general uniformity in present designs dates from about 1878. The distinctive features in them at present being due chiefly to economical considerations.

As I mentioned before, the early wooden bridges and some of the iron ones were not designed or proportioned on any very correct theory. They were largely empirical structures. As an illustration: Mr. Kirkwood, an able engineer of the time, wrote—"The heavy locomotives used in the freight traffic of railroads and the great speed of express passenger trains, render massive strength in all railroad bridge structures essential. The many bridges which have been strengthened since they were built, and the many which have had to be removed and replaced by stronger structures, sufficiently attests the mistaken economy of erecting light and cheap frame bridges. The blind confidence which the best of carpenters are apt to have in the raw material of their trade and in the rude geometry of its usual combinations, has rendered them unsafe guides to engineers in the planning of bridge trusses involving irregular and shifting strains, with which their general practice cannot make them familiar. Hence it is that even now the engineer will always find it not merely a safe but a necessary rule to make his bridge trusses heavier and stronger than the most intelligent professional carpenter of his acquaintance is likely to consider necessary." So the best the engineer could do was to make his bridges stronger on the basis of past experience.

The first attempt to analyze the strains in bridge trusses was by Squire Whipple, in 1847, but the results were not widely known for some time.

The use of one ton per foot, uniform load for designing

all parts of a railroad bridge, was in general use up to 1860, and later in many instances. In 1870, a heavier uniform load began to be used to design the floor system, than the truss, and in 1876, the use of actual concentrated loads, as existing in a train, were specified by Mr. Bouscaren for the Cincinnati Southern Bridge, at Cincinnati. Rolling loads have steadily increased in weight, and at the present time the M. C. Railroad's, which are among the heaviest loads specified, are two engines coupled, each weighing 123 tons, followed by a uniform train load of 4,000 pounds per lineal foot of track. In our practice we add a percentage to the above induced strains for all spans under 100 feet, determined by the formula ($1\frac{1}{3}$—L÷300) in which L is the length of span in feet.

Highway bridges should be designed to carry, in addition to their own weight, 100 pounds per square foot of floor surface, a traction engine weighing 11 tons, or any other especially heavy load they may have to carry. The 11 ton traction engine, which has recently been put upon the market in this State, is the heaviest single load, to my knowledge, that the ordinary highway bridge will be required to carry. We have recently had to strengthen the floors in our overhead bridges, to make them safe for this loading. The engine will generally govern in designing the floor of a bridge, and 100 pounds per square foot of floor surface for the main truss members.

The advent of iron construction involving the use of a more expensive material, compelled a better consideration of the relation of the parts of a truss to the duties to be performed. The investigation made during the building of the St. Louis bridge, into the strength and other properties of materials of construction, and the testing of full sized members and their detail connections, gave a great advance in knowledge of these matters. Comparatively little was known before this, but the deductions from these tests awakened a desire for a better knowledge of the form and proportions of bridge members, and as a result most of our large bridge companies to-day have testing machines to test sample pieces or full size material. Every railroad company that is now abreast with the times, and is cognizant of the value of good material over that which

may not be, has its bridge material inspected at the mill, both chemically and physically. The inspection should be followed through very carefully, all of the material in a bridge. It is not sufficient that one or two melts out of several should be tested and conclude that the others will be like these. Every melt should be tested, and then it is known as thoroughly as is possible, the exact quality of all the material. Without this thoroughness a great deal of the advantage of inspection is practically lost, and any laxity in this respect would have its effect in the deliberations of a jury.

Steel has lately supplanted wrought iron for use in bridges. Its cost is less than that of iron and it is stronger. Compared with wrought iron, soft steel has 15% higher ultimate strength, 20 to 25% higher elastic limit, and 50 to 70% greater ductility. It has equal strength, ductility and bending qualities, lengthwise and crosswise of the material, while wrought iron strained across the grain has little strength and ductility and will not bend. Further, steel has no fiber and consequently less disposition to tear and pull out, and is capable of a finer finish. The Carnegie Mills have stopped making wrought iron, their exclusive output being steel. It can be obtained in three general grades, the soft, medium and high steel. So that the different members of a bridge can be made of a grade most suitable for the work to be done, according to the ideas of the engineer.

Steel is made by two general processes, the Bessemer and open-hearth. The Bessemer output is considerably the largest, but the open-hearth process is considered by a great many to produce a more uniform and better product. Many of the leading engineers of the day will not permit the use of Bessemer steel in bridges at all, and Mr. Waddell goes so far as to specify that any attempt by manufacturers to substitute Bessemer steel for open-hearth will be sufficient cause for cancelling a contract. The advantage of open-hearth steel is that it is a more uniform product, and so less liable to have any excess of the objectionable element phosphorus. It has proved a more reliable material, for in the case of failure, sometimes due to shop manipulation, sometimes to shock when under stress,

and sometimes from unaccountable or mysterious reasons, it has generally been traced to the Bessemer product.

Phosphorus is the particularly objective element in steel, its presence in too large quantities making the steel very brittle and treacherous. It should not be allowed to exceed .08% in amount. The other elements, carbon, silicon, sulphur, etc., may vary in amount with less effect. Some engineers, however, give limits for these elements, but by specifying a certain ultimate strength, elastic limit, % of elongation, and reduction of area, with a maximum phosphorus limit, a good steel can be obtained, leaving the other elements to the option of the manufacturer. So in getting steel for bridge purposes, the method of manufactnre should be specified, the chemical composition to a certain extent, and the physical properties.

The open-hearth steel can hardly be discerned from the Bessemer, from a surface inspection, and consequently the first duty of the inspector is to see that the open-hearth product is obtained.

In the manufacture of steel in the bridge shop, care should be exercised to have about three-sixteenths of an inch of metal removed from all sheared edges. In shearing and punching, the steel undergoes a small injury; the surface is compressed or displaced next to the cutting tool, reducing the area and having the effect of reducing the ductility and ultimate tensile strength. This injury is less in soft steel which is not more than three-eighths of an inch thick but increases as the steel becomes thicker and with the higher grades of steel. Steel over three-fourths of an inch thick had best be drilled, as the injury from punching becomes too extended. Steel under three-fourths of an inch thick should be punched one-fourth of an inch in diameter less than the finished hole, and reamed to full size. Tests have been made showing that a steel bar three inches by five-eighths of an inch is reduced about 15 per cent. in strength by punching alone. But by punching and reaming, as indicated above, the strength remained hardly impaired. No advantage is gained in the medium thickness of steel by drilling. The punching and reaming showing up equally well, and is cheaper.

The painting of bridges to protect them from rusting, is a subject which has not been given the careful attention in the past, which is warranted. Iron exposed to the air and moisture, will rust or oxidize, and if not protected would rapidly lose its strength; much more rapidly in some localities than others. The first requisite of good painting is to have a clean and rustless surface. If paint is put on over an imperfectly cleaned surface or rust, moisture will get in, the paint will swell and burst, and oxidation go on. It is a difficult matter to have iron properly cleaned in the shop, and a certain amount of rusting will take place while the iron is being shipped from the mill to the bridge shop, it oftentimes being stored out of doors for some time. To obviate this I would recommend that iron be given a coat of pure raw linseed oil before it leaves the rolling mill. This will protect it up to the time of manufacture at the bridge shop. After manufacture it should be retouched with oil to cover rivet heads and parts where the oil has been rubbed off. And after erection in the field give it two good coats of paint. This painting had best be done by the corporation for whom the bridge is built, and by day labor, not contract. The advantage of using raw oil instead of boiled is that you may be sure of a pure article. The advantage of oil over paint for a first coat, is that rust and scale cannot be concealed from view, so that when you come to paint the bridge yourself, you may be ensured of a perfect surface for the paint to adhere to.

An iron bridge properly protected would probably last forever, while one which was carelessly looked after, might not last twenty-five years,

The life of a railroad bridge, so far, has been determined by its ability to carry the increased loads over those for which it was designed. The question comes up in our office very often, is such a bridge, built a number of years ago, safe for our present heavy trains?

With regard to paints, red lead and oxide of iron are the leading ones. Each of them have many advocates, but I think the consensus of opinion favors red lead. We have just finished painting the iron bridges on the entire system of the M. C. Railroad, and used the following mixture: Sixty-four pounds

dry red lead, 12½ pounds graphite paste (manufactured by the Detroit Graphite Manufacturing Company), and 3¼ gallons of raw linseed oil. Figuring the lead at 5½ cents per pound, the graphite at 8 cents per pound, and the oil at 55 cents per gallon, will bring the cost of this mixture to $6.44, or a little over $1 per gallon. This is more expensive than the oxide of iron, but will cover more surface. We mix the paint as it is used, as we are sure thereby of getting pure ingredients, and red lead should be applied before it has stood very long after mixing. Mr. Bouscaren states that under favorable conditions oxide of iron will last three years, and that red lead will last six years.

Most all of the old type of bridges are things of the past. Present practice is pretty uniform as regards the type of structure for different spans. Our practice is to use riveted plate girders or rolled beams for spans under 90 feet, riveted lattice bridges for spans between 90 feet and 130 feet, and pin connected trusses for spans over 130 feet. The plate girder bridge is the most expensive, but is the most popular structure, and the best one, on account of its rigidity, and the absence of parts to get out of order. It is particularly desirable on railroads, as it presents no impediment to the passage of loaded cars, which the through truss does. The question is constantly coming up, can a car with a certain load clear the bridges safely on a certain part of the road? Besides, the danger from derailed trains is reduced to a minimum, and the danger of projections from loaded cars knocking out some of the members of a truss, entirely done away with. It is our practice to build several short spans of girders, in preference to one long span, if the waterway can be obstructed to the extent of placing piers in it. The lattice bridge is cheaper than the girder, and its rigidity especially commends it in preference to the pin truss. The pin connected truss is cheapest for all spans, and for the longer spans is sufficiently rigid to compare favorably with the riveted truss.

Wooden floors are beginning to be discountenanced in first-class bridges, their places being taken by the iron and ballast floor. There are several designs of these in use upon different roads, but I think the one designed by Benjamin Douglas,

Bridge Engineer of the M. C. Railroad, superior to other designs, in that the ballast, which is one foot of gravel, does not come in contact with any part of the bridge which undergoes stress. This floor is made by placing I beams crosswise of the bridge, one foot apart, the entire length. On top of these beams is a solid flooring of three-eighth inch plate to hold the ballast. The latter being confined on the sides by a line of angle iron. A coat of Byerlyte about one-fourth inch thick is put on the iron plate to prevent it from rusting. The cost of this floor is about $6.50 per lineal foot more than the wooden floor, as we build them. The advantages of this floor are, less danger from fire, the maintenance of a smoother track, the dispersion of forces due to power brakes, through the ballast, and the approach to static in mechanical effect of imposed loads.

The present bridge should be designed with reference to the future and should be liberal in the quantity of material used and judicious in its selection and manufacture. The bridge, besides being designed for actual work required to do, should be designed with forethought for what it might have to do in case of derailment or other emergency. To obtain these results, the bridge engineer acting for the corporation for whom the bridge is built, is a necessity. The competition on bridge work at the present time is so fierce that the engineer of a bridge company is allowed no latitude and is forced to keep his design down to as low limits as his intelligence and shrewdness will furnish him the means so to do. If he does not, he will not get contracts and his company will not be long in need of his services. Besides proportioning the main members to as low an amount as allowable, the detail connections can be sacrificed to a very undesirable amount, when good strong concentric connections could just as well be obtained. It is just as important to have an inspector follow the work through the shop and see that first-class workmanship is obtained as it is for you to watch an architect or builder in case he was building a house for you. I am sure that any of you would not allow an architect or builder to go ahead and build a first-class house for you for a certain amount of money, without giving your careful attention to every detail. This is of more im-

portance with the bridge, to ensure safety, as near as is possible, to the hundreds of human lives which daily have to make use of them.

Mr. Hodgman.—Mr. Duncan, in his paper, was speaking of the effect upon the iron of punching or drilling holes. Does the addition of a small percentage of aluminum to the iron or steel make any difference with the drilling qualities?

Mr. Duncan.—I am not very well posted on that subject, because I don't think it is a question that has come up in a practical way, but I should think that the effect of the use of aluminum would be to lessen that difficulty, because it makes a softer quality of steel. I understand that aluminum is being extensively used in the manufacture of iron and steel. It has not been used in bridge engineering iron—structural iron, to my knowledge. I have heard it talked of for castings, but I don't know of its being used.

Mr. Dryshall.—It is used in castings. It makes better castings, but I never heard of it as used in steel.

Q. What percentage brings the best results?

A. I don't know—just a small percentage.

Mr. Pashby.—I have been told that it is a practice of bridge companies, in bidding on a contract, to put all the bids at a sufficiently high figure so that the successful man can whack up with the unsuccessful bidders. How that may be, I can't say. I hope it isn't so. As the speaker has said, bridge building is a science, and the average man who has to deal with the contractor, is utterly incompetent to deal with him. He knows nothing whatever about determining the stress in the different members of a bridge. Now may not this condition of affairs be remedied in some such manner as this:

May not the regents of the University and the State Board of Agriculture be requested to authorize members of the engineering departments in those two institutions to undertake the inspection of plans submitted, and the inspection of the bridges, if necessary?

We have a precedent for this in the matter of fertilizers. As some of you know, if a man wishes to retail a fertilizer in

this state for more than $10.00 per ton, he must pay a license of $20.00, and some sample of his wares, purchased in the general market, is analyzed by the chemist at the experiment station at Lansing.

Now will it not be a parallel case to have plans and specifications submitted by the Bridge Companies, inspected by the engineers at these two schools, who are competent to do the work? At the present time, those departments are worked to their full capacity, but it might be necessary for a time that this work be borne by the present force, as it is not likely that the boards having the contracts to let would take advantage of any such offer, and perhaps the work could be borne by the present force, but in the event of their being crowded, the State could well afford to pay an engineer to make these examinations. It is well known that the local boards are very much averse to paying an engineer for any such work as that —they don't see, as a general thing, the necessity of making a very heavy outlay, but I believe if some such thing were offered to them, free, that many would take advantage of it. I am strengthened in that opinion by a talk which I had with a highway commissioner in the southern part of the state a few weeks ago. I determined to start an investigation of the way in which bridge companies are dealing with the Highway Commissioners throughout the State. The only man I have talked with, up to the present time, was a Mr. Goodrich, of Gentreville, St. Joseph County, and during the last summer, in that Township, two bridges have been built.

I asked Mr. Goodrich to let me take whatever plans, specifications and data he might have on these bridges—left him by the companies who put them in. He said he would be very glad to let me take them and what I got, lies on the floor by my desk at the college. They consist of two blue prints, and it seems as if the company had studiously avoided putting on them sufficient data to determine what the bridge was good for. In one case the length of span had been omitted, and also the capacity of the bridge. The factor of safety was omitted in both cases. On the other, the height of the spans was omitted, although the length of the spans and

the capacity is supposed to be given, 125 pounds per square foot.

Now it seems to me, that the next best thing to having an inspector to look over the bridge during the process of construction, as suggested, would be to have the companies leave sufficient data so that these details may be inspected afterwards.

As an illustration of what may be done by the companies, I had the privilege of reading a contract that was made with a Board of Commissioners in New York some time ago, in which they had inserted this little, innocent clause: "The Bridge Company reserves the right to change the form of cross section of any member, if they keep the area," or words to that effect. That binds the Board of Commissioners—places them completely at the mercy of the company having the bridge to construct.

Take compression members—change the form of cross-section and they may be utterly worthless. These are extreme cases, yet it seems to me that the Society would do a good thing for the people of the State of Michigan if they could inaugurate some means of giving the Highway Commissioners a fair chance with the Bridge Companies.

Mr. Sears.—There may be profit in it, to the Highway Commissioners; perhaps they will object.

The President.—It has always seemed to me that the farmers had that matter all in their own hands. There are plenty of competent engineers who would be glad to render their services for a very modest amount—to pass judgment on the sufficiency of any plan, and I find that in villages, and small communities, fully as poor as a township of farmers are generally, when they come to put in a water works or electric light plant, they uniformly call upon someone with sufficient knowledge to put them in possession of the data, so that they can enter into a contract intelligently, so that the ends of justice will be fully met. In the matter of bridges, which it seems to me is considerably more difficult work than the preparation of plans for water works, and a matter harder for the average man to apprehend, they hire some fellow, or elect him, as Highway Commissioner, and pay him $1.50 a day to go

and take entire charge of passing upon the sufficiency of a bridge plan. In this state, the Town Board and the Commissioner together, can, by the expenditure of a modest sum, get, in a good many towns in this state, an engineer to pass upon it. While the matter of submitting it to the University and Agricultural College professors would be a safe one, yet it would be drifting into a form of paternalism, which I don't believe is a good policy to adopt in our form of society and government. The object of dividing into townships, is to enable people to control their own local affairs.

Mr. Douglass.—I don't, myself, believe in the State taking much charge in the construction of bridges, although I wish we could educate the farmers and the township authorities sufficiently to make them understand that it was profitable to hire an engineer.

Mr. Granville.—It is not possible for an honest company to do business with these small towns; if a company wants to build a bridge in a small town, it has got to do it cheaply. While I don't believe in cheating, still it drives the good companies out of business, and I think the farmers themselves are to blame.

Q. If you were going to settle the blame for this whole matter somewhere, where would you put it?

A. It rests on the farmer. If they don't insist on having a good article, they won't get it. The trouble is, they think if an engineer charges $25.00 for passing his judgment on a matter, that he is cheating them, and they would just as soon be cheated by the bridge company as by the engineer.

Mr. Rogers.—I have heard of a plan that struck me as being very good, and it will perhaps put bridge companies on their guard. I don't suppose that we can expect that the farmers will, much before the millenium, see fit to hire an engineer sufficiently able to pass upon the bridge when they build it, but I think if there were a law requiring every company putting up a bridge anywhere in the State, to file detail plans of that bridge with some officer in the State, even if they were not examined at the time, and then if anything happened to the bridge and it was shown by the examination of these

plans by an expert that they were not up to specifications,—

Col. Muenscher.—That leaves it for the autopsy.

Mr. Rogers.—Yes, but bridge companies might be afraid of the autopsy.

Mr. Hodgman.—I was going to suggest another thing, that is not original. The State of Michigan undertakes to say that if an insurance company does business in this State they must show that they are sound, and then if anything is wrong, it must be made right. They must put up a guarantee. What sort of a scheme would it be to make the bridge companies put up a similar guarantee? Let the bridge companies make their own designs, and say nothing about it. All we ask them is to say, "We will put you up such and such a bridge, and we guarantee that for such a time, that bridge will be good and what we represent it to be." That relieves the whole question, places the whole responsibility with the bridge company to do what they agree.

Mr. Douglass.—Any bridge company will guarantee its bridge, because it is reasonably certain it won't get the load designed for it, and, in fact, there are very few bridges in this State which would stand a crowd of people on them, I think, and the chances of a bridge company having to pay damages from a bridge falling down are so slight, that it would take the contract and build them just the same, and when a crowd of people did get on, they would go down and the people would be killed.

The President.—The sale of a bridge involves the same commercial principles as the sale of a suit of clothes does, and it is supposed that both parties shall know their business. If the purchaser does not know what constitutes a good bridge, it is his business to find out, and if he puts up a bridge that is unsafe, it would be well enough to settle the blame on the Township officers. They are paying the money out; you can't get two dollars for one dollar, and they are the responsible parties. That is where the responsibility ought to be placed, and not on the bridge company, who are there with their skinning knives, in competition with each other, and these

people invite the skinning. If a farmer is skinned through his lack of good horse sense, it is his own fault.

Mr. ————.—That would answer very well if it were simply a question of dollars and cents, but the lives of the public are being exposed, by these poor substitutes for bridges, and it seems to me there ought to be some sort of control exercised, as over insurance matters, infectious diseases, etc., anything that threatens the life of the public.

I like Prof. Pashby's proposition very well. In some States, I think they have State Engineers, whose business it is to pass upon bridge plans, and that project was at one time proposed in this State—the appointment of an engineer, whose business it should be to examine all plans before acted upon; but it is not simply the adoption of the correct plan. That would be all right, but you must follow the thing out—see if the plan is complied with, and the right sort of material put in. Now the ordinary engineer, though he may be competent to pass upon the adequacy of the plans for a bridge, cannot, as a general thing, determine whether the material is good or not. It must be followed up at the rolling mill, and the bridge works —the workmanship and quality of material must be tested at the time. After it gets on the ground, to be put into the bridge, the local engineer cannot do anything about it. He can only see that he has the right size.

Mr. Hodgman.—That raises the question in my mind, how far inspection inspects, in the manufacture of iron. In the first place, how many engineers are competent to make such an inspection, and in the second place, suppose they are, how far can they carry it out? I have been led to believe, in connection with some of the developments in armor work, where they attempt rigid inspection, for the United States, that it is a question whether you can carry out a system of inspection that will be thoroughly satisfactory.

Mr. Douglass.—I think the inspection at the mills is very satisfactory; at some of the smaller mills, there is perhaps some cheating done; at the larger mills, I am pretty confident there is not. They cannot do it. They are turning out an immense amount of steel, and it is all stamped with the mold

numbers, and these molds are tested, and they haven't time to stop and substitute; it would cost more to substitute poor material for the good, than it would amount to. In the armor plate—that was inspected by men who didn't know much about it, and there was a great deal at stake.

Mr. Hodgman.—The discussion in connection with that was what I had reference to—as to the practicability of carrying out a thorough system of inspection in those large iron works.

Mr. Douglass.—You must depend partly on the maker, and the fact that they cannot very well substitute. They stamp all the material with the mold numbers, as it comes from the mill. This is done by a man who does not know what it is or where it is going, and they are not likely to attempt to substitute, for it won't pay, even supposing they were willing to do it.

Col. Muencher.—I don't think the difficulty lies so much in the rolling mills, because they have their reputations to sustain, but these "tin" bridge companies don't care much for their reputations.

Mr. Douglass.—I guess some of the rolling mills don't care much either; some will cheat you if they can, but then there are a good many that won't, and as I say, the larger ones can't very well, except that they might substitute a piece occasionally. In the bulk they can't substitute, because it would cost more.

As to inspection by the State; I think if the State is to do anything, it would be better to have an engineer on purpose for that—an engineering department, and charge the cost to the Township authorities where the bridge was built, and they would have to make it compulsory on the Township authorities to employ a competent engineer or have the work done by the State engineer and be charged for it.

Mr. Appleton.—Wouldn't it work about like our banking commissioner, who is to prevent all banks from breaking, and the insurance commissioner, who guarantees that the insurance companies shall all keep the faith?

A. It would depend largely on the engineer; if you could eliminate politics, it would be all right.

Mr. Duncan.—In connection with my paper, I wish to state something about the erection of bridges; in erecting our new bridges in place of old ones, we do it very rapidly, erecting the new bridge on false work, one side of the old bridge, and if the old bridge is a wooden trestle construction, we get the new bridge up in proper shape, with the ties and rails on, and get the use of the track for perhaps half an hour or so, and throw out the old bridge. We have made the change of a span 150 feet long, in 27 minutes, and it has been only thirty-five minutes between the actual passage of a train of the old bridge and the new one. This is necessary, in order not to delay traffic.

The President called upon Mr. Granville to speak.

Mr. Granville.—I unfortunately did not hear that paper read, and have heard but little of the discussion. I hardly know what you want to hear from me, or what I can say.

The President.—We want a cure for the present system of bridge building—we want honest work.

Mr. Granville.—I don't know that I care to give away any of the secrets of the trade, but it strikes me that to secure the best results, the engineer, I don't mean a general engineer, but a man who is competent to design a bridge, should be employed for all bridges of any importance, at any rate, to prepare plans for these different townships or counties or cities, or whoever is going to construct the bridge, and proposals should be received upon that one plan, from all the companies competing for the work. Usually they advertise for proposals, and each company submits its own designs It is a very nice thing for the bridge companies, because it affords an elegant opportunity to do some leg pulling, and very frequently it enables a man who is somewhere near the top to pull the contract, although he may not have a design as worthy as the man who has bid lower, but on account of his nice show plan, and ability to talk, he succeeds in pulling the contract his way, while there would be less chance of doing that if all were bidding on the same design, and that a good one, prepared by someone not connected with the contracting firms.

Mr. Elder.—A certain city in this State built a bridge a

few years ago. It was a 50 foot span, and 35 feet wide, and in asking for bids, the only condition made was that it should come up to Cooper's specifications for class A Highway Bridge, the design being left to the company, and the bid accepted was for a pony truss; the contract was made out so that the company should be held rigidly to Cooper's specifications, and the plans submitted were looked over by a general engineer, and I believe he also went to the works and examined into the process; the bridge was found to be all right, except five or six points which were changed, and it was accepted in every point, except that the floor was not quite up to the standard, and $50.00 was held back.

The contract price for the bridge was $2,250 for the span. The amount of iron in the bridge was figured, and the cost seemed rather high. It was, however, the lowest bid, and was accepted. Afterwards it was hinted that it was rather higher than it ought to have been, and it was found that the bridge could have been built for $1,700 or $1,800. Now the question was, did the representative of the bridge company, who made that contract, with the men who let it, all gathered together at one time, did he make a donation? If so, how can it be brought about that a contract can be bid for without allowing them to make these donations?

A. They can do it by hiring an engineer who is posted in the business well enough to know the commercial price of the materials.

Mr. Riggs.—It seems to me that the whole of this matter is the fact that the people are not willing to trust the engineer. If they have a case of typhoid fever, they trust a doctor, but the majority of common councils want to do their own engineering, or a large part of it. The specialty of bridge engineering is entirely separate and distinct from general engineering, and the man who is in general practice is neither competent or qualified, as a general rule, to pass with thorough understanding on matters of this sort. It seems to me that in some way or other, a thoroughly competent bridge engineer, a specialist, should be selected. The matter of the preparation of plans and specifications should be left to him. He should

ask for and receive bids, and submit the bids or a synopsis of them, to the proper authorities with a recommendation. He should name the inspector, and in that connection, it is immaterial whether the contractor shall pay for this work, or the people, or the company, but it is proper and right that they should name their own inspector and have him report to them, but if the whole thing is left to one man, and he prepared the plans and specifications, if he is a competent man, the chances are that the work will be better done, and then the people will know where to place the responsibility; that is the feature that now it is impossible to locate. If you have a bridge builder, you don't know whether to blame the contractor, the engineer or the trustees or councils, or the authorities representing the people.

It seems to me simply a matter of the competence of the engineer, and the recognition of the fact that bridge engineering is a specialty, entirely separate from other classes of engineering work.

Col. Muencher.—I think that idea is correct. To tell the truth, there isn't one person out of ten competent to pass judgment upon bridges. A man must make it a very careful study, to be able to test the correctness of the plan, and as for making a plan himself, there is hardly one man in ten who can do it. He must be familiar with the method of calculating strains, he must be practical, or he will get in sizes that are not marketable and compel the making of new patterns and add a great deal to the expense of the bridge. A man ought to be specially qualified for bridge engineering before he is allowed to pass upon the adequacy of plans.

Mr. Granville.—It is hardly fair to condemn bridge companies too severely for some of their practices. Of course there are many things they do practice that are to be condemned, but you must take a great deal into consideration.

You would be surprised, those of you who have not run against the thing, the amount of corruption there is among the ordinary country officials; it is, in many cases, impossible to do business or make a contract without first doing a little business with some of these farmers, and often, it does not take a great

deal to do it, either. Ten dollars goes a long ways. There is this element to be met with in this kind of work, and bridge contracting is, I think, peculiar to itself. I have done contracting in a number of different lines, and since I have gone somewhat into the line of bridge contracting, I have gained an experience which I never had anticipated, and struck things which were way beyond anything I had met with in other lines of contracting.

Mr. Douglass.—I think there is no doubt about the remedy —the proper remedy for this trouble. I think Mr. Riggs has stated the medicine very well, but how are you going to administer it?

Mr. Granville.—The Engineering News of a few weeks ago discussed this point which our Kalamazoo friend brought up. How are you going to stop pooling among bridge men? They, it seems to me, take a sensible view of the question, and if any of you are interested in the matter, I would refer you to your back numbers of the Engineering News. It is there discussed in a very rational manner.

Mr. Sears.—I think the thing can be simplified, if the counties as a community, would change their system. In this county we have fifty supervisors. A few months ago we wanted an appropriation of $500 to make some repairs on the Court House. We had to call a three days' session to get permission to raise that $500. That cost $518 to allow an expenditure of $500. Now if that system could be changed, and that force reduced to five competent men, they could do the work of this county in less time than the fifty, and you might include among them, one competent engineer. I think these bridges should be taken out of the hands of the Township officers.

Motion made, supported and unanimously carried, to extend a vote of thanks to Mr. Duncan for his paper.

EFFECT OF FREEZING UPON CEMENT.

BY E. W. MUENSCHER, C. E.

The Committee which was appointed at the last Annual Meeting of the Michigan Engineering Society, for the purpose of investigating the effect of freezing upon cement, being composed of gentlemen scattered all over the State, the manifest impracticability of bringing them together for consultation has suggested the idea that each member should make his own investigations and present his own conclusions. While, therefore, the writer, as Chairman of the Committee, has felt it his duty to the Society to investigate the subject more thoroughly than he might otherwise have done, he desires it understood that no other member of the committee is responsible for anything that he might say.

The subject, of the effect of frost upon cement mortar and concrete, is one which is of great interest to every Civil Engineer and practical Mason, and yet it is one that is very imperfectly understood. This is, no doubt, owing to the fact that but few engineers have ever been called upon to deal practically with the problem. For many years there has been a very general impression that frost is injurious, and for that reason the profession, almost without exception, has endeavored to avoid all masonry construction during freezing weather. It is a very common thing to find in specifications for masonry a provision that no work shall be done between the months of November and April, or some other equivalent period, the only object of this provision being evidently to avoid the effects of frost.

That this provision is a wise one, when circumstances permit its enforcement, there can be no question, for all experience confirms the correctness of the general impression of the injurious effects of frost, at least in some degree, and it is never good policy to run unnecessary risks. In the great

majority of cases it is perfectly practicable to suspend work during the winter, and some of the prominent engineers in the country, in reply to the writer's enquiries as to their experience, have stated that this has been their invariable practice. There are numerous cases, however, in which this would be impracticable. On our navigable canals most repairs and new work in masonry cannot be done without drawing off the water, and must therefore be postponed until after the close of navigation. Many manufacturing establishments in the Northern States make all their repairs and extensions during the winter, because during the rest of the year they are operated to the limit of their capacity, often day and night, and cannot be shut down for repairs without great loss.

In all such cases, where the construction of masonry in freezing weather cannot be avoided, it is of great importance to know: First, how frost affects cement; second, what is the rationale of this effect; third, how this effect can be avoided or remedied. These are questions which can only be answered by experiment, and yet, up to a very recent period, no such experiments had been made, unless we regard as an exception the practice of putting salt in the water with which mortar to be used in cold weather was mixed, which had become quite common years ago. So long ago as 1856, the writer finds in his notes of Prof. W. M. Gillespie's lectures to the Engineering classes of Union College, the following remark:—"If common salt be mixed with cement, say a peck to a bushel, the mortar made with that may be used for laying masonry in freezing weather. This is practical on the canal work." This was all that the Professor told us on the subject, and most likely it was all that he knew.

Within the past few years, however, this subject has been exciting much interest, and a number of experiments have been made which have thrown much light upon points which had previously been quite obscure and imperfectly understood. The writer feels that he cannot do any better service to this society than to lay before it the results of these experiments, so far as they have come within his knowledge.

The first series to which your attention will be invited was

conducted during the winters of 1890-1891 and 1891-1892, by the Cement Committee of the Austrian Society of Engineers and Architects. In response to a request for advice, from the Contractors for the construction of a new theatre at Zurich, Switzerland, in the prosecution of which it was necessary to lay some masonry in winter, the reports of these experiments were published in the Society Journal for February 16, 1894, and a quite full translation of the report can be found in the Engineering Record, Vol. XXIX, Page 251.

For the benefit of those members of this society to whom none of these means of information are accessible, we give the substance of this report.

"The experiments were made in two ways, the first with brick masonry and the second with rubble masonry, using stone of two kinds, in order to determine whether there was any difference between materials which were unlike hydroscopically." It is important to note that "the materials used were dry and free from snow and ice, and the mortar was mixed as stiff as possible," a condition not always met with in practice. The separate pieces of brick wall tested were about 1 meter long, 2 meters high and 12 inches thick and was made with lime, Roman cement, Portland cement, a mixture of lime and Portland cement, and Slag cement. The mortars used were mixed with unwarmed water from the City mains, and with water warmed to 77° Fahrenheit. Tests were also made with Roman and Portland cements and cold water to which 7 per cent. of its weight of cooking salt had been added. All mortars were made with 1 part of cement and 2 parts of sand. In the mixed mortars twice as much lime as Portland cement was used.

The lower half of the walls was partly protected by timbers, but the upper portion was entirely exposed. A few tests were also made with brick masonry laid with Hansleitner's frost-proof Roman and Portland cements.

The test-blocks of rubble masonry were 1 meter long, 2 meters high and 16 inches thick. The stone used was partly limestone and partly sandstone. These blocks were made with lime mortar, Roman cement mortar and Portland cement

mortar, mixed with cold and hot water and cold brine, as before. The brick walls were started the last part of December, when the temperature was 26° Fahrenheit, and finished in about three weeks, the lowest temperature being 3° Fahrenheit. They were pulled down June 6.

It was at once apparent that the walls laid with mortar containing lime had suffered more from frost in the exposed upper portions than in those protected by timbering, since in the former the water had plainly been frozen. The joints were then examined with a sharp iron, with the following results:—

1. Lime mortar mixed with cold water—The mortar in the joints had hardened but feebly, and the bricks could be pulled apart by hand without exercising any noticeable amount of strength.

2. Lime mortar mixed with warm water—The mortar in the joints had hardened feebly, and there was no adhesion between the bricks and the mortar.

3. Roman cement mortar mixed with cold water—The mortar in the outer and inner joints had hardened moderately, and there was considerable adhesion between the bricks and the mortar.

4. Roman cement mortar mixed with warm water—The joints were quite brittle and the inner portions of the mortar not particularly well hardened; the adhesion between the bricks and mortar was quite good. The part of the wall protected by timbers was in better condition, and excelled any of the preceding walls.

5. Portland cement mixed with cold water—The joints were hard and the mortar clung well to the bricks. The protected part was better than the other in this case.

6. Portland cement mixed with warm water—The joints were hard, the mortar adhered well, and the entire piece of wall was a little better than any of the preceding.

7. Lime and Portland cement mortar mixed with cold water—The mortar was badly mixed, brittle and crumbling, but adhesive.

8. Lime and Portland cement mortar mixed with warm water—The mixture was uniform in this case, but the mortar

was brittle and not well hardened in the interior, although adhesive.

9. "Frost-proof" Roman cement mortar mixed with cold water—The mortar was well hardened and there was a good adhesion between it and the bricks. A plaster of the same material, put on a part of the wall, was thoroughly hard and without sign of injury.

10. "Frost-proof" Roman cement mortar mixed with warm water—This mortar was well hardened and adhered very well to the bricks. A plaster of the same material was thoroughly hard and without defects.

11. Wittkowitz Slag cement mortar mixed with cold water—The joints were brittle and the mortar fell into little particles when scratched out with the iron. The inner parts, which had hardened somewhat, were crumbling and showed but a slight adhesion to the bricks.

12. Wittkowitz Slag cement mortar mixed with warm water—The condition of this wall was but slightly better than of that last noted.

13. Roman cement mortar mixed with cold water, to which 7 per cent. of its weight of salt had been added—The mortar was brittle and crumbling, adhering but slightly to the bricks.

14. Portland cement mortar mixed with cold water, to which 7 per cent. of its weight of salt had been added—The mortar was well hardened throughout and adhered well to the bricks.

The masses of rubble masonry were started on December 28, and completed about two weeks later, the temperature ranging from 7° to 25° Fahrenheit. They were examined April 7, and found in the following condition:

A. Limestone rubble.

1. Lime mortar mixed with cold water—The mortar was completely frozen and brittle, and without any adhesion to the stones. The block had fallen completely.

2. Lime mortar mixed with warm water—The mortar was entirely frozen, brittle, and without adhesion.

3. Roman cement mortar with cold water. The mortar had hardened pretty well, but had not the slightest adhesion to the stones, which could be removed from their beds without injuring the latter.

4. Roman cement mortar with warm water. The mortar was quite well hardened, but did not adhere in the slightest degree to the stones.

5. Roman cement mortar mixed with cold water and salt. In this block there was a partial adhesion between the stone and cement, and the latter had hardened somewhat better.

6. Portland cement mortar with cold water. The mortar had hardened very well, and the adhesion between stones and mortar was quite good.

7. Portland cement mortar with warm water. The conditions were the same as with the last block, although the adhesion may have been a trifle greater.

8. Portland cement mortar mixed with cold water and salt. The mortar was very hard and adhered to the stones very well. The tearing down of the wall required considerable strength and necessitated the use of bars and other tools.

B. Sandstone Rubble.

1. Lime mortar with cold water. The mortar was entirely frozen brittle, easily broken, and without a trace of adhesion to the stones.

2. Lime mortar with warm water. The condition of this block was the same as that of the first.

3. Roman cement mortar with cold water. The joints were badly frozen, the mortar crumbling and slightly hardened. There was no regular adhesion between it and the stones.

4. Roman cement mortar with warm water. This block was in the same condition as the last.

5. Roman cement mortar mixed with cold water to which salt had been added. The mortar was well hardened and adhered fairly to the stone.

6. Portland cement mortar with cold water. The mortar was well hardened, but its adhesion to the stones was only partly good.

7. Portland cement mortar with warm water. The conditions were much the same as with the last block.

8. Portland cement mortar mixed with cold water to which salt had been added. The mortar had hardened very well and adhered firmly to the stones. The block could not be broken apart without tools.

The conclusions of the committee from these experiments are, that in brick masonry laid in frosty weather mortars into which any part of lime enters should not be used. Roman cement mortars behave fairly well under such conditions and Portland cement mortars give good results. The use of warm water gives somewhat better results and salt materially increased the resistance to frost. With rubble masonry, using either sandstone or limestone, lime mortar was entirely out of place, and Roman cement mortar gave poor results unless mixed with salt. Portland cement mortar behaved well, especially with the addition of salt.

The final recommendation of the committee is, that in laying brick or rubble masonry in winter, only Portland cement mortar should be used, mixed with salt, if possible.

Two young students of Thayer School of Engineering, Dartmouth College, Percy L. Barker and Henry A. Symonds, give in their graduating thesis an account of a series of experiments which they made to determine the effect of freezing on the strength of cement mortar. This thesis can be found in full in Engineering News, Vol. XXXIII, page 282, but the substance is given below.

The experiments were made upon prisms of mortar one inch square and five inches long. Six brands of cement were used, Newark, Hoffman, Alsen, Saylor's American Portland, Giant Portland, and Improved Union, which is a mixture of Portland cement and natural cement. The cement was mixed with sand in proportions of 1 to 1 and 1 to 2 and the mortar pressed into molds. When the prisms had become thoroughly set they were exposed in the open air until frozen, and after remaining in this condition for intervals of from 2 to 60 days were tested by cross-breaking. A few tests were made with prisms of neat Rosendale cement and a large number with

prisms in which salt had been mixed with the mortar in various proportions, mostly 1 part salt to 30 parts water.

The conclusions drawn by these young men, from over 7,000 tests, were as follows:

1. Portland cement mortar suffers no surface disintegration under any condition of freezing, but the strength is injured in a majority of cases, and sometimes as much as 40 per cent.

2. Rosendale cement is disintegrated upon the surface when exposed to frost while setting, the amount of injury depending to a certain extent upon the number of degrees of the exposure below the freezing point. Extremely low temperatures produce a greater effect upon the cement than temperatures near the freezing point.

3. The cohesion of Rosendale cement mortar may be entirely destroyed by immersion in water which becomes frozen around it.

4. In the case of Rosendale cement an increase of strength appears to be acquired under the conditions which it passes through while frozen.

This of course means the strength of that portion of the prism which is not disintegrated, and it is very questionable whether this conclusion is a correct one.

5. Salt used in the mixing water, in proportions varying around 1 salt to 15 water, assists the Rosendale cement to resist the disintegrating action to frost to the greatest advantage, but appears to have an injurious effect on the strength.

6. The Improved Union gives eminently satisfactory results. It shows the property of Portland cement as allowing no surface disintegration, and gives the characteristic of Rosendale cement in attaining an excess of strength under frost.

They also regard the following points as suggested by the results of their own and other experiments:

1. That Portland cement mortar is injured relatively less by freezing as the ratio of cement to sand decreases.

2. That Portland cement mortars are injured relatively less by the action of frost as the ratio of salt in the mixing water increases to as high as 1 to 15.

3. Lime, if of the proper quality, may be used with fairly

good results in brick masonry if kept constantly frozen for some time after laying, but is ruined by alternate freezing and thawing.

This conclusion is directly contradictory to that of the committee of the Austrian Society, and seems to have been based solely upon an examination of the mortar used in the masonry of paper mills at Olcutt Falls, Vermont. "Various mortars were employed on different parts of the works, as follows: Portland cement mixed with from 1 cement to 2 sand to 1 cement to 7 sand by volume. Rosendale was used with the same proportions of sand as the Portland. In the brick masonry an excellent quality of gray lime was used alone in the mortar and also mixed with Portland cement. The masonry was constructed in cold weather, a small amount being laid when the temperature ranged as low as 35 degrees below zero. The Portland cement mortar was in excellent condition. The Rosendale cement mortar had scaled to some extent, especially when exposed to the extremely low temperature before setting. At a few points the mortar was found to be softened into the body of the masonry, but was generally hard below the first half inch. The lime when mixed with Portland cement showed not the slightest injury from frost; when used alone in the mortar it appeared to act in a similar way to the Rosendale cement."

The writer is also indebted to this thesis for some other data which were not otherwise accessible to him.

Mr. George S. Morrison exposed a pail of water in which specimens of Rosendale and Portland cement were immersed to freezing. The water became solid to the bottom. Upon thawing the ice, the Rosendale specimens were found to have been reduced to sand, while the Portland specimens showed no injury. Hoffman Rosendale cement mortar was laid late in the fall around the waste way of the reservoir of the Hanover (N. H.) water works, and water stood around and upon it, more or less, during the winter. When examined in the spring, the upper layer was found to be little more than a mass of dust and scales. The same brand of cement laid in the masonry of the gate house of the same reservoir during cold weather

showed disintegration to about one-fourth inch depth, but seemed in good condition beneath.

In the report of the Royal Testing Laboratory of Berlin of 1886, an account is given of a number of experiments made to ascertain the effect of frost upon the strength of Portland cement neat and mortar made of 5 parts sand to 1 part cement. Two distinct series of briquettes were made, the first being exposed to freezing on and during the sixth day after mixing, while the second were treated as follows: (1) Allowed to set twenty-four hours in a warm room; (2) exposed twenty-four hours to freezing; (3) thawed four hours in a warm room; (4) immersed until tested. Upon testing the specimens it was found that the effect of freezing varied with the quality of the cement; the loss of strength by freezing ranged from 2 per cent. to 22 per cent. in the cement and from 3 per cent. to 24 per cent. in the mortar at seven days.

After 28 days a deterioration was shown of from 2 per cent. to 12 per cent. in the Neat cement and from 1 to 33 per cent. in the mortar.

The use of pulverized clay from a blast furnace gave a still greater loss of strength from freezing.

Mr. Wm. W. Maclay, C. E., in a paper in Transactions of the American Society of Civil Engineers, Vol. VI, gives the results of a series of experiments performed by him upon the effect of heating the ingredients of cement mortar and using the hot mortar at freezing temperatures. All the experiments were made with Burham cement. Two sets of briquettes were used. In one set the temperature of the cement paste averaged 40 degrees and the other 100 degrees Fahr. The sets were treated exactly alike and broken at the same time. The strength of the heated mixture was found to be only from 7 per cent. to 20 per cent. of that attained by the cold mixture. In the case of mortar made of 1 volume of cement to 2 of sand, the heated showed a strength of only 30 per cent. of that reached by the cold. Mr. Maclay concluded that the use of highly heated materials in mortar greatly reduces its normal strength. This conclusion differs very widely from the experience of many masons, and inasmuch as it does not appear to rest indisput-

able theoretical basis, and so far as known to the writer has not been confirmed by subsequent experiments, it should be accepted with hesitation if at all.

Mr. Alfred Noble, in Transactions of the American Society of Civil Engineers, Vol XVI, states "that in the construction of a lock at St. Mary's Falls Canal, the laying of masonry was discontinued about October 20 of each year, on account of the frequent recurrence of freezing weather. On the last day of work done in 1877 mortars of Portland cement and of a good quality of American natural cement were used in adjoining portions of the wall. The same proportions of cement and sand, 1 to 1, were used in both classes of mortar. This masonry was laid during a light rain. The following spring the surface of the Portland cement mortar was sound, showing perfectly the marks of the rain drops. The natural cement was disintegrated to a depth of 3 or 4 inches."

Mr. Noble also gives the results of some experiments upon Portland cement mortar with different proportions of salt in the mixing water. "Two series of experiments were performed, the first indicating no marked effect when the amount of salt was increased, while the second series showed a less effect from frost as the amount of salt was increased."

Mr. J. J. R. Cross, in Transactions of American Society of Civil Engineers, Vol. III, states that "mortar laid in the construction of a masonry dam in winter on the Croton River, where salt was used, gave perfectly satisfactory results. One pound of rock salt was dissolved in 18 gallons of water (about 1 to 150 by weight) at 32 degrees Fahr., and for each 3 degrees lower temperature three ounces of salt additional were used."

"Mr. J. F. Wallace used a brine of 8 per cent. salt in the mortar laid during cold weather in the construction of the Sibley bridge over the Mississippi River. The masonry showed no signs of injury from the low temperature to which it was exposed."

In "The Final Report on the Tennessee River Storage Project," by Geo. W. Rafter, C. E., to the State Engineer of New York, 1894, for which the writer is indebted to the courtesy of Albert J. Herries, C. E., Assist. Eng. N. Y. State Ca-

nals, the following passage occurs: "An experiment was made in a very rough way as to whether these concretes would stand winter weather when freshly made. For this purpose the surplus quantities of each mixing were made into a series of cubes of three feet, these cubes being built up in thin layers, well rounded, from day to day, as the tests went on. Block No. 1 was composed of Wayland cement for the first foot at the bottom, with the balance natural. No. 2 was about the same except that there was a layer of Portland cement concrete about one inch thick at the top. Block No. 3 was natural cement concrete, except a layer of Portland cement concrete six inches thick, about eight inches from the top. No. 4 was composed entirely of Portland concrete, except a layer of natural cement concrete about six inches thick and about six inches from the top."

Plate No. III in the report is from a photograph showing the appearance of these blocks March 17, 1894. Blocks No. 1 and 2 appear to have been reduced to shapeless masses. In block No. 3 the layer of Portland concrete appears thoroughly indurative and, so far as can be observed, entirely uninjured by frost.

In block No. 4 the Portland cement concrete is uninjured while the layer of natural cement near the top has crumbled the same as in the other blocks.

The boxing was allowed to stand around all these blocks until after the completion of the tests in December. They were therefore protected from the action of storms at the sides until after thorough setting had taken place.

The test by exposure to freezing indicates one point wherein the Portland cements, as a class, are superior to the natural, namely: they may be laid in moderately cold weather and, provided as small an amount of water as possible is used, no ill effect will be observed. The water is the destructive agent in freezing weather, and by reducing it to a minimum there will remain after chemical combination, little or none to disrupt. This practice, too, will be of advantage by adding to the strength of the mixture, as it is now well understood that an access of strength of the concrete follows a reduction of the

amount of water used in mixing; for the greatest strength the smallest possible quantity of water should be used. For very great strength the quantity of water may be so far reduced as to cause the mortar to resemble moist earth. When such mortar is added to broken stone which have first been well wetted and allowed to drain, the water may, by thorough ramming, be still flushed to the surface in a very thin film.

In freezing weather, therefore, the practice which prevents injury to the work will also be the proper practice for developing the greatest possible strength.

It has been a common practice to add salt to the water used in mixing in freezing weather in the proportion of about one per cent. of saturation for each degree below the freezing point. The weight of evidence is that for well proportioned Portland cement, this practice is entirely wrong—much better results will be obtained by the practice indicated in the foregoing.

Mr. S. D. Steele in a note to the American Society of Civil Engineers says: "Cement mortar is not seriously injured by being laid in frost, as its property of setting is simply held in suspension during the time it remains frozen."

Gen. Q. A. Gillmore, in his work on Coignet Beton, says "The effect of freezing on newly made beton is to detach a thin scale from the exposed surface," but "the injury does not extend into the mass of the material unless the frost be very intense." Also, "When the temperature ranges but slightly below the freezing point during the day, work may be safely carried on if care be taken to cover the new material at night. After it has once set and had a few hours to harden, neither severe frost nor alternate freezing and thawing has any effect upon it."

The following is an extract from a letter to the writer from Mr. Albert J. Herries in reply to an enquiry as to the practice on the new Lake Canals. "The subject is a highly interesting one and it is to be greatly regretted that while very large quantities of cement are used by us annually in freezing weather, we are still without any careful and scientific record of its behavior. However, while we cannot give you

any refined dates about the behavior of the cement, we have the most satisfactory of all tests, the test of many years of actual use, and I can say without any reservation that when the construction has been under the care of competent engineers, we have never had any difficulty or any bad results from cement mortar used in freezing weather. Our experience has been confined mainly to the use of natural cements and it has been our practice to use a saturated solution of salt in mixing the mortar, and to clean all stone thoroughly from dirt, snow and ice. We lay stone in as cold weather as men can work in, which in our damp climate is about 10 degrees F. The brine is tested with a salinometer; sometimes a potatoe has been used, but our proximity to the Nutmeg State has suggested to the minds of ingenious and economical contractors that wooden potatoes are more durable and are not injured by freezing. We therefore resorted to the salinometer.

"On lock 3 of the Cayuga and Seneca Canal in the spring of 1870, the masonry was completed so late that the mortar did not have time to set, and when water was let into the canal, the mortar washed out of the joints causing considerable trouble. We all think that salt retards the setting of the cement. No other experience of the kind has come to my notice."

It will be observed that the fact that natural cements are largely and successfully used on the New York canals seems to flatly contradict the conclusion of some experimenters that only Portland cement can be used with safety in freezing weather.

For the following three letters the writer is indebted to Mr. Dorr Skeels, a member of this committee.

The first is from G. S. Greene, jr., Engineer-in-Chief Department of Docks, New York City.

"In reply to yours of the 29th, ult., requesting some information in regard to the effect of cold and freezing weather on cement mortar and concrete, I beg leave to say in reply to your first question that much depends upon the use to which the mortar or concrete is to be put. If the concrete or mortar is to be subject to washing by water or if it is for any

reason desirable to have it set hard and quickly, the higher the temperature, that is natural temperature, the more satisfactory would be the result, because on the general principle that heat accelerates the chemical action, it would set quicker and harden in a short time. If, however, the concrete or mortar is simply to remain in air or in any position undisturbed, the slight acceration of the chemical action will not be of any particular advantage. In regard to your second question—'Is cement mortar made at 40 degrees Fahr. injured?' I think not, and in long experience have never known any to be injured at that temperature. In regard to whether the cement mortar is injured at 32 or 25 degrees, it is hardly practicable to mix mortar or concrete and set stones with the mortar or ram the concrete into position at 25 degrees Fahr. without heating the materials and possibly the tools with which it is handled. I have done work a number of times where the concrete was frozen, and the chemical action suspended by the cold, but where the concrete was not disturbed for 6 or 8 months, and found that the chemical action was simply suspended during the continuance of the cold weather, and as it became warmer the chemical action took place and the concrete set and became perfectly good work.

"My general instructions in making concrete in cold weather are, where it is not to be disturbed after being put in position, that it may be made as long as the materials do not freeze to the tools, or as long as the mortar does not freeze so that it cannot be worked with a trowel, or, in case of concrete, cannot be rammed."

The second letter is from Fr. von Emperger, C. E., from which the following extracts are taken:

"The German practice is not to work below 28 degrees F., mainly because working men quit work in colder weather. It is different in Norway where 12 degrees F. is taken as a limit.

"The only additional experience which I have is that even with 28 degrees in places where the wind blows or the sun has no access there may be a further depression, and it is also difficult to watch with a thermometer in the hand. I adopt the rule to always use salt if the water shows freezing, or the

stone. Nevertheless it is unavoidable that in stopping work the surface may get frozen before set if a sudden cold falls in, if not quickly and well covered, so that in starting again we cannot determine which part is frozen and which is not. We have then to pour hot water on the joint and scrape away all the loose material.

"Cold weather is always preferable for concrete work because it is generally damp, and I consider heat and drought more dangerous for fresh concrete than cold weather, because dry mortar concrete is absolutely valueless. It is further of advantage in work in connection with a water way to shut it off in winter while it is not in use. A further reason is that expanded walls may get cracked in winter while walls built in cold will expand without injury.

Mr. P. Amann, an Australian Engineer, has made some of his largest works during hard winters, and this time with trained men and proper precaution is generally commendable, but otherwise the general German code is good enough."

Mr. M. Murphy, Provincial Government Engineer, Halifax, N. S., furnishes the following items:

A paper read before the Institute of Civil Engineers, Great Britain, by A. E. Carey, on the inspection of Portland cement, in dealing with temperature, says:

The temperature of the water used for concrete making also deserves consideration. The experiments given in Appendix IV show the effect of freezing briquettes at various stages and for different lengths of time, and demonstrate that in cement, gauged as it is in making briquettes, frost produces no deleterious effect, the setting properties being rendered dormant thereby, and the long term tests being practically identical with those maintained at a higher temperature. In concrete making on public works, in which an excess of water is generally used, the effect of frost is to disintegrate the concrete by the expansion of the water in freezing, and measures to neutralize this effect have been investigated by the Russian and American authorities.

It has been found that the addition of common salt to the water enables work to be carried on during hard frosts, the

proportion of salt so employed even reaching 8 per cent. A temperature of 75 to 80 degrees Fahrenheit was found by experiment to hasten the maturing of the cement, a result to be noted in relation to work in tropical waters.

APPENDIX IV.

EFFECT OF FROST UPON CEMENT BRIQUETTES.

No. 1 Series.—Gauged in water of 55 to 60 degrees Fahrenheit, and immersed at a similar temperature, the tensile breaking strain was 540 pounds at seven days and 585 pounds at fourteen and twenty-eight days.

No. 2 Series.—Gauged as above, and exposed for forty-eight hours (setting being unusually slow) to temperatures ranging between 30 degrees Fahrenheit maximum to 22 degrees Fahrenheit minimum; then placed in water exposed in the open air. The temperature during the following five days ranged between 41 degrees Fahrenheit maximum and 22 degress Fahrenheit minimum, the briquettes being imbedded in ice. After seven days test, the temperature was slightly above freezing by day and 2 or 3 degrees below at night, but the ice did not thaw on the surface of the water. The tensile breaking strain amounted to 357 pounds per square inch at seven days, 552 pounds at fourteen days, and 395 pounds at twenty-eight days.

See Vol. CVII, Minutes of Proceedings of the Institution of Civil Engineers, pages 55 and 67.

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Mr. Carey's remarks may hold good when Portland cement concrete or Portland cement mortar is employed "en masse," such as in foundations and under water where the temperature may be uniform, and where the crystalization can be homogeneous throughout the entire body. When employed in work above the surface, such as in piers or walls having an exposed and varying in temperature, the results may be different.

Immediately after the concrete material is deposited in a plastic condition, it undergoes quite a change to a higher temperature, while, on the outer or exposed surface with a lower

degree, the same conditions cannot exist; and though the different thermal conditions of change, within and without, may be small, we cannot doubt that the total effect produced by these changes is considerable. Hence, as in small crystalline bodies, cooling and setting under similar conditions, cracks will invariably occur.

If the work has been carried on in a temperature of 45 degrees Fahrenheit the changes through the mass will be so small that there cannot be any deleterious effects. If we have a temperature of zero outside, whilst within the body it is very much higher, the setting or crystallization which takes place in the cooling, cannot be uniform or homogeneous, and different results must be expected.

The intermediate temperatures, such as that of 25 degrees Fahrenheit must also, more or less, affect cement mortar or concrete. In Nova Scotia, the changes of temperature may vary from 10 to 15 degrees Fahrenheit in a few hours. When working late in the season I have been caught by these sudden changes and my experience has been such that, when the temperature approaches the freezing point of 32 degrees Fahrenheit, I immediately stop the work. I have built ashlar masonry in Portland cement mortar when the thermometer stood at 10 degrees Fahrenheit, and sometimes lower, and found the work in fair order the following spring. I could not, however, recommend that concrete work above the surface be performed in a temperature of less than 32 degrees Fahrenheit, even then the face of the work is liable to disintegration.

During the summer season, when it is above 75 degrees Fahrenheit, the same deleterious effects will take place, and the same remarks may be applied in an ascending scale. In hot weather exposed concrete should be kept covered and frequently damped with a sprinkling of water to ensure smooth and solid face work.

In cements other than Portland, such as natural cements, where the quantity of free lime is greater, the deleterious effects must be proportionally greater. Where cement mortar is used in masonry in very cold or freezing weather, the ex-

posed points ought to be raked out and pointed when the season is more favorable.

The Engineering Record, Vol. XXIX., page 59, in an editorial reply to a correspondent, says: "If Rosendale cement must be used in freezing weather it would be better to use salt water (perhaps 1 or 2 per cent. solution). Many good cements are not sensibly affected, although even a little salt probably slightly impairs the strength at advanced age. The initial effect of the salt is an acceleration of the hardening of the cement.

Mr. Charles Robert, Engineer of the Western Railway of France, gives in "Le Genie Civil" his experience in handling mortar for masonry in freezing weather. His company had tried mixing alcohol and marine salt with water, and finally adopted the ordinary soda of commerce. This latter gave the best results in reducing the liability of the mortar to freeze; and in the winter of 1891–2 a considerable amount of masonry of all kinds was laid on the line, even in a temperature of 5 to 14 degress F. above zero. Among the works executed was an arch of 50 feet span, with the masonry laid up in lime mortar without cement. From his experience the following rules for mixing the soda with the mortar have been adopted. He used the hydrous carbonate obtained by the Solway process, as it costs less for transportation and hand labor than the hydrated carbonate. This soda comes powdered in sacks. It is dissolved in a kettle in which is constantly maintained a desage of 1 kilogram (2.2 pounds) to 5 litres (5¼ quarts) at a temperature of 86 degrees F. This solution is mixed with an equal volume of ordinary water in the tubs from which the masons obtain the water for the mortar. This is used at a temperature of 50 to 53 degrees F. In preparing the mortar the proportion of water usually employed in a mortar of 1 part sand to 1 part lime should be increased about one quarter. Sand frozen on the surface should be carefully pulverized and it is well to provide the workmen with rubber gloves. The increased cost due to the admixture of soda, with the soda at 4 cents per kilometer and at 7 cents per hour for hand labor, is about 37 cents per cubic yard of masonry.

Mr. Robert says that the addition of the soda not only makes it possible to mix the mortar and to preserve it in a low temperature, but it also hastens the setting. With the proportions above given, the soda mortar exposed to a temperature of 23 degrees F. has set twice as promptly as the same mortar without the soda at a temperature of 14 degrees F. At the surface for a depth of .16 to .20 inch, the hardening is much quicker. The interior during the setting process remains humid. This has been proven by pulling down masonry after five months, and when exposed to the air the mortar dried rapidly.

These results have been obtained with masonry exposed to the air. With the mortar immersed in water strongly impregnated with soda, the set has been much accelerated. The use of soda causes white blotches to appear on the surface of the masonry; but these disappear after some months. This fact and the persistent humidity of the interior, practically forbids its use in the fronts of buildings, but it may be used in all other works.—[Eng. News, Vol. XXIX, page 146.—Eng. Record, Vol. XXVIII, page 348.

Mr. Bernhofer, an Austrian Engineer, has had a similar experience with soda. In December, 1890, he used a mortar consisting of 1 litre of Portland cement, 1 litre of lime and 3 litres of river sand mixed with a solution of 1 kilogramme of crystalized soda in 2 litres of water. This mortar was exposed to a cold of maximum intensity of 31½ degrees below zero (Cent.) for 14½ hours, and was then put into a hot furnace for 3 hours. At the end of that time the set of the cement was found to be perfect.—[Eng. News, Vol. XXIV, p. 316—Vol. 26, p. 203.

These experiments would seem to show that an admixture of soda is an effectual preventative of the injurious effects of frost, but its much greater cost would seem to forbid its use instead of salt if salt will answer the purpose.

There appears to be quite a general opinion among engineers that the strength of cement mortars and concretes is considerably lessened by mixing with and immersing in salt water. Gen. Gillmore, in his work on "Limes, Hydraulic

Cements and Mortars," page 166, expresses this opinion founded upon some experiments of his own, and this opinion has been generally accepted.

Mr. F. Collingwood, in a paper before the American Society of Civil Engineers, November, 1895, states that a certain cement which gave excellent results when mixed with fresh water was inferior to others when salt water was used.

More recent experiments by Mr. Elliot C. Clarke, in connection with tests of cement for the Boston Main Drainage Works (Tran. Am. Soc. C. E., Vol. XIV, p. 155) with both Rosendale and Portland cement mortars mixed with both fresh and salt water and immersed in both fresh and salt water, seemed to indicate "that salt either in the water used for mixing or that of immersion has no important effect on the strength of cement, except to slightly retard the first setting."

Still more recent tests by Mr. John Gartland from May, 1889, to July, 1890, on 15 different brands of cement and 2,531 briquettes, "showed in every instance but one (Hoffman Rosendale, 2 months) that cement used with salt water is much the stronger. The favorable effect of the salt seemed more marked on Rosendale than on Portland cements. The permanent gain in the strength on the former seemed to be about 20 per cent., more or less, while on Portland cement at least 10 per cent. gain was indicated."—[Eng. News, Vol. 24, p. 542.

Mr. M. J. Powers, in some laboratory experiments extending over 13 weeks on 3,500 briquettes of both Portland and natural cements, arrived at the conclusion that cement mixed with salt water gains considerably in strength during the first few weeks, but that the gain is not permanent; that the gain is greater and more permanent with the Portland than with the natural cements, and that the effect of using a 10 per cent. solution seems not as good as with a 3 per cent.—[Eng. News, Vol. XXVI, page 481.

Mr. Walter Katte's General Specifications for Railroad Construction contains the following provision: "Masonry may be laid in freezing weather by using salt water for mixing the mortar. Dissolve one pound of rock salt in eighteen gal-

lons of water when the temperature is at 32 degrees F. and add one ounce of salt for every degree lower of temperature, or enough salt, whatever the temperature may be, to prevent the mortar from freezing. No masonry laid in freezing weather to be pointed out until spring." Precisely similar specifications have been used at Scranton, Pa., and other cities.

The Specifications of the Metropolitan Sewerage System of Boston, 1890, provides: "When work is done during freezing weather the contractor shall provide the necessary means for, and shall heat the bricks, gravel, sand and water, and shall comply with all the requirements of the engineer to thoroughly protect the masonry from damage from frost during and after laying. No work shall be done on masonry during such days as, in the opinion of the engineer, good work cannot be done,—all unfinished shall be properly protected during inclement weather from injury from water or frost."

Similar provisions may be found in other specifications where reliance seems to be placed entirely upon heating the materials.

Prof. Baker in his "Treatise on Masonry Construction," says: "It does not appear that common lime mortar is seriously injured by freezing, provided it remains frozen until it has fully set. The freezing retards but does not entirely suspend the setting. Alternate freezing and thawing materially damages the strength and adhesion of lime mortar. Although the strength of the mortar is not decreased by freezing, it is not always permissible to lay masonry during freezing weather; for example, if, in a thin wall the mortar freezes before setting and afterward thaws on one side only the wall may settle injuriously. Mortar composed of 1 part Portland cement and 3 parts of sand is entirely uninjured by freezing and thawing. Mortar made of cements of the Rosendale type, in any proportion, is entirely ruined by freezing and thawing. It is probable that this difference is due to the fact that the expansive force of water in freezing is less than the strength of the richer Portland cement mortars and greater than any Rosendale cement mortar. In the latter case freezing is equivalent to agitating the mortar after it has partially set. Mortar

made of over-clayed cement (which condition is indicated by its quicker setting) of either the Portland or Rosendale type, will not withstand the action of frost as well as one containing less clay; for since the clay absorbs an excess of water, it gives an increased effect to the action of frost. Thus far we have confined ourselves mostly to the conclusions of engineers and scholars derived from experiments on a comparatively small scale and largely, perhaps, under conditions different from those which occur in actual practice. We now add some data from the experience of practical masons and contractors.

Mr. Wm. H. Ward, a contractor who had occasion to put in many thousand cubic yards of Portland cement concrete for street railways in Brooklyn, much of which was done in the winter, thus describes the material which he employed in cold weather: "A large water-tight tank, open at the top, was constructed, of such dimensions as would allow three ordinary dirt boxes to be lowered into it at the same time. This tank was filled with water and a jet of steam kept the water hot in the coldest weather. The broken stone or cobbles, designed for the concrete, were loaded into these boxes and lowered into the tank of hot water. A bath of a few minutes duration heats the stones to the temperature of the water. One of the boxes is then hoisted out and dumped on one side of the mixing machine, the stone with sand and water in proper proportions is run through the machine and wheeled to the place of deposit without delay. In this way with layers ten or twelve inches deep, well warmed, the heat is retained until the cement becomes firmly set and makes an almost impenetrable mass. In severely cold weather additional protection is secured by heating the sand and water before using. When the temperature is low it is well to protect the work by a cover of hay, gunny cloth, or other convenient material."—Engineering News, Vol. XXXI, Page 181.

The following letter to the writer gives the valuable experience of a mason who has had an unusually large practice in winter work, some of it in the extreme climate of Northern Michigan:

MANISTEE, Mich., Dec. 3, 1895.

I have been requested to give my experience in the use of cements and quick lime mortar in winter or freezing weather, and will try to do so as a practical mason. My first experience was in the winter of 1853–54, at Jonesville, Mich., working with my father, who had the contract to build the brick chimney, 64 feet in height, and set the engine and boilers for the woolen mills at that place. We used the Ohio lime and Akron cement. We slaked our lime dry in sand in cold, freezing weather, and after mixing it with the sand sifted and mixed it for use as we needed it. This kept it from being frozen before using, and we used care in selecting dry brick, so the moisture would be absorbed from the mortar as quickly as possible when laid in the wall, and then the frost would not swell and burst the joints, and destroy the beauty and strength of the wall, which would be the case if the brick were wet or frosty and the mortar cold, as then the frost would form ice in the joints of mortar and swell and destroy them, as I said before, instead of helping to absorb the moisture and set the points, as it would if the brick were dry and the mortar warm. I have found in all cases where such care has been taken that walls laid in the very coldest weather are stronger than they would be if laid in the heat of summer, for the reason that the mortar dried slower and adhered firmer to the brick. And in using cements of every kind I have found the same care necessary as regards drying of frost out of the stone or brick used, so that there would not be sufficient moisture left to form ice and swell the mortar. Wherever these precautions have been taken the work has always been good, and I write this after forty years' experience, north and south, on house, store and mill work. I can refer to plenty of such work done in the coldest of our Michigan weather which is standing today and is the best proof of what I have here written. I will mention a few of them that I have had personal supervision over: Dempsey and Manistee Lumber Company, boiler house; Eureka Salt and Lumber Company, boiler house and engine foundation; the boiler house and engine foundations and furnaces of the Buckley & Douglass Lumber Company, the Jacob Aarons stores, First Congrega-

tional Church, and the furnaces of the Canfield & Whalen Company, all of Manistee, Mich; my old home in Jonesville, Hillsdale County, the Government Rolling Mill at Chattanooga, Tenn., furnace and stack built under direction of William Bettilar, U. S. Engineer, in 1864–65, and many others which I could call your attention to, that are in good condition to-day that were built from 1853 to within the last few years, on which I have worked or have had charge of.

WM. T. BRAIN,
Brick and Stone Mason and Contractor,
380 First St., Manistee, Mich.

Mr. Brain's experience includes the use of common lime, Portland and natural cement, and much of his work was done under very unfavorable circumstances, that at Chattanooga when it was freezing and thawing every day, and some of that at Mainstee in the very coldest weather when, the work would freeze as fast as it was laid, and a mason could not work without overcoat, mittens and ear-tips, and a large part of a bucket of mortar would freeze hard while the rest was being used. It will be observed that his success has been based upon the use of as dry materials as possible, and he also recommends using hot sand and water and heating the stone enough to take out the frost.

The reader, on looking over the mass of material which we have here presented, will readily observe that there is a wide difference of opinion among engineers and practical men on several points.

One claims that common lime mortar is worthless in freezing weather, another has used it with perfect success; one claims that natural cement mortar is destroyed by frost, another points to its successful use for many years. Some say that the use of salt diminishes the strength of mortar, others that it increases it; some that salt retards the setting, others that it hastens it. One uses an extra dose of water in freezing weather, another uses the least possible quantity. Some recommend heating the materials, while others claim that heat injures the mortar. At first sight one almost feels like exclaiming with the showman, "You pays your money and you

takes your choice." It is plain that the subject has not been reduced to an exact science and that there is still wide room for careful experiment. It would seem, however, that from the mass of facts it is possible to deduce some principles.

The setting of mortar is largely a chemical process requiring as an essential element a certain amount of water in a liquid form. Frost by changing this water into the solid form of ice destroys its power of chemical combination in the same manner as if it had changed it into particles of sand, and the process of setting is stopped. It has the additional effect of causing the disintegration of the mortar by the expansive force of the water in freezing, unless it has acquired sufficient internal strength to resist this force. This effect is evidently less as the amount of moisture in the mortar is diminished. It would seem then that any process would be useful which, without injuring the quality of the cement, would retard the freezing until the process of setting is completed or is sufficiently advanced to resist the action of the frost. This would be a sufficient explanation of the useful effect of salt, soda, heat, protection and the removal of surplus moisture. Assuming that these conclusions are correct the writer ventures to suggest the following rules to be observed in part or in full when it is necessary to construct masonry in freezing weather.

1. Use Portland cement in preference, if practicable, if not, those brands of Rosendale cement or common lime which have shown the best behavior.

2. Mix the mortar or concrete in a spot sheltered as much as possible from cold winds.

3. Use the least amount of water that will be sufficient to enable the mortar to set.

4. Heat the water and sand for the mortar and the broken stone or gravel for concrete. Warm the brick or stone for masonry sufficiently to remove the frost, but not enough to make it difficult to handle.

5. Mix salt with the water in the proportion of 1 pound to 18 gallons of water at 32 degrees F. and one ounce additional for each degree below 32 degrees.

6. Use the mortar or concrete as quickly as possible after it is mixed, before the heat is dissipated.

7. Protect the unfinished masonry as much as possible from cold winds and cover it at night or when work is suspended.

8. Leave the pointing of the masonry until warm weather.

B. F. La Rue.—In a recent conversation with Mr. Geo. Leighton, who was assistant engineer on the masonry work of Washington Bridge under Mr. Alfred Noble, Resident Engineer, Mr. Leighton made the following statement concerning work done in freezing weather:

"This work was in progress during the winter of 1887–88. Portland cement was used for laying the arch stones, in face walls and below water line, while Rosendale cement was used in backing and interior walls. A considerable amount of both was laid in freezing weather, a certain quantity of salt being sprinkled upon all mortar mixed in such weather. Instructions were that no masonry should be laid with more than 20 degrees of frost (below 12 degrees above zero). I made frequent and careful examination of the work laid in freezing weather and took notes of its condition.

"In masonry laid in freezing weather with Rosendale cement, when examined in a frozen condition the mortar was found to show decided efflorescence, the salts of the cement upon its surface having the appearance of hoar frost. At such examinations it was my opinion that the mortar would be much injured. But when again examined in the spring, after the frost had disappeared, the essential portions of the mortar joints were found to be in excellent condition. No difference could be discerned between this mortar and that laid in warmer weather, except that in the mortar laid in freezing weather the surface of the joints had crumbled away to a depth of about a quarter of an inch, exposing a perfectly hard and firm mortar beneath,

"The Portland cement mortar was found to be in all respects perfect and apparently unaffected by the frost."

Mr. W. H. Sadler, Assistant City Engineer of Scranton, Pa., a gentleman of extensive experience in masonry construc-

tion, gives the following opinions as the result of his observation and experience:

"In using mortar in freezing weather, I would protect the mortar box from the wind and would sprinkle just enough dairy salt upon the mortar to prevent freezing. I would also heat the sand and heat the water, putting some salt in the water. A small proportion of water should be used and the mixing should be very thorough as well as rapid. Too much water is used in very many cases. Dairy salt is better than rock salt. Only sufficient salt to keep the mortar from freezing should be used. Too much salt makes the mortar slippery and discolors the work. The freezing of mortar is most troublesome in the morning.

"In my opinion the effect of frost upon Portland cement mortar is not directly injurious, except that it retards the setting. The damage to the work is that the freezing of the mortar prevents the workmen from properly bedding the stones. Heavy work can be constructed in freezing weather more advantageously than light work. It would be inadvisable to attempt to lay thin walls or work having close joints in freezing weather, or to do any pointing. Hydraulic work laid in freezing weather would be very apt to leak. I would not attempt to use natural cement in freezing weather. When the temperature falls below 10 degrees above zero, I would suspend all masonry work unless very urgent."

M. J. Becker, C. E., Past President of the American Society of Civil Engineers, says, "As a mere matter of precaution I have, in my own practice, always made it a rule not to build any masonry in cold weather; in a few instances, where I could not adhere to this rule and had to build some brick arches in tunnels, I took my chances, presuming somewhat upon the sheltered location, and continued work during cold weather, and I found that the mortar used in pointing the joints, which was Louisville cement and contained but very little sand mixture, scaled off in the succeeding spring and had to be repointed. Perhaps pure Portland would have given better results."

(COMMENTS ON PAPERS IN THE ENGINEER'S ANNUAL FOR 1895.)

CEMENT AND CONCRETE.

A More Simple System of Testing Cement.

B. F. LA RUE.

In discussing Mr. Hillyer's valuable paper on the above subject, read at the last annual meeting, Col. Muenscher stated that "What the average engineer wants is a more simple system of testing," and in this connection referred to the graduating thesis of two engineering students, having for a subject the testing of cements.

These young men, Herman E. Abbott and Edwin J. Morrison, made a large number of tests of various cements, 1,438 in all, for the purpose of determining their strengths, both in direct tension and in flexure. (See Engineering News of Dec. 14, 1893, and May 10, 1894). I believe the latter method of testing cement to be worthy of further attention and venture to offer the following observations along the line suggested by Col. Muenscher and as supplementary to his remarks.

Testing by transverse or cross breaking stress would seem to be the most rational as well as the most simple method of determining the practical value of cement. The principal disadvantage of this method of testing is that the strength of the cement, as computed from transverse tests by applying the common theory of flexure, will not be the same as when obtained by testing the same cement in direct tension. Cement is weaker in tension than in compression, and, when broken by flexural stress, rupture will occur on the tension side of the beam. It would, therefore, seem as though the tensile strength of this material should be indicated by flexure tests. But the strength of cement, as computed by applying the common theory of flexure to cross-breaking tests, is, roughly speaking, found to be nearly one and three-quarters times the strength

of the same cement broken in direct tension. This was shown by the tests of Messrs. Abbott and Morrison referred to, in more than 500 of which tests very just comparisons between the two methods of testing were afforded.

The explanation commonly given for this somewhat phenominal disparity in the results obtained by these two methods of testing, is that the common theory of flexure does not apply after the elastic limit of the material has been exceeded. This difficulty, if insurmountable, would prove a severe obstacle to the testing of cement by transverse stress. I do not wish to here attempt any theoretical discussion of this subject, but simply to call attention to a simple formula by the use of which this disparity of results may be practically reconciled, so far as the testing of cements be concerned.

According to the common theory of flexure, the moment of resistance of any beam is given by the formula, $R=\frac{SI}{c}$ in which R is the moment of resistance, I is the moment of inertia of the cross section, c is the distance of the most remote fiber from the neutral axis, and S is the unit stress in this remote fibre. As stated above, when applied to flexure tests of cement this formula will give values for the unit stress much in excess of the strength of the same cement tested in direct tension, and the same is quite generally the case when applied to transverse tests of other materials.

Now, I have noticed that by substituting the radius of gyration, r, for the distance, c, in the formula $\frac{SI}{c}$, thus giving it the form $\frac{SI}{r}$, the results obtained by applying the formula to transverse tests of such inelastic materials as cast iron and cement will agree very closely with the strengths of the same materials as obtained from tension tests. By comparing on this basis, 896 flexure tests of cement, made by Messrs. Abbott and Morrison, with 542 tension tests, made by them on the same cements and under as nearly as possible the same conditions, the average difference between the results obtained by the two methods of testing was only 6 per cent.

which, for a material as variable as cement, is as close as could be expected. These tests had been made with especial reference to obtaining a comparison between the two methods of testing and, consequently, the comparison is fair and reliable.

Therefore, without reference to the theoretical features of this formula (I am aware that it is not supported by accepted theory), I believe that I am justified in recommending it as a reliable formula by which to compute the breaking stress in flexure tests of cement. The only claim which I here make for the formula is that it will, in all cases and for all forms of cross section, give practically the same results as tension tests of the same material. As this claim appears to fulfill all requirements for a formula for computing the results of flexure tests, I will put it in a form convenient for practical use.

For a beam of rectangular cross section, the expression $\frac{S\,I}{r}=\frac{S\,b\,d^2}{3.464}$, in which b is the breadth and d is the depth of the beam. If it be a simple beam of span, L, loaded midway between its supports with a single load, W, we will have $\frac{W\,l}{4}=\frac{S\,b\,d^2}{3.464}$, from which $S=\frac{.866W\,l}{b\,d^2}$. If the beam is a rectangular prism of a cross section one inch square and S be taken to represent the ultimate strength per square inch, we will have S=.866Wl or, for convenience in remembering, we may say that the stress per square inch is equal to the product of the center load W, the span, l, and the sine of 60 degrees.

I give below the value of S in terms of W for prisms one inch square on various spans of convenient length. In each case, S is the ultimate strength per square inch and W is the load applied midway between supports.

For l=2 inches, S=1.732W (W×1.73).
" l=3 " S=2.598W (2.6W).
" l=3½ " S=3.031W (3.03W).
" l=4½ " S=3.897W (3.9W).
" l=5 " S=4.33W (4⅓W).
" l=6 " S=5.196W (5.2W).
" l=7 " S=6.062W (6.06W).

The values in parentheses are near enough for practical purposes.

I would recommend as a standard that the prisms of cement be made one inch square and seven inches long; that the original prisms be first broken on a span of 5 inches and the shorter pieces thus obtained be broken upon a span of 3 inches. The prisms should be exactly one inch square, the length of the span should be accurate and the load should be applied exactly at the center of the span.

One advantage of the method of transverse testing over that by direct tension is the greater percentage of good breaks that can be obtained. In testing cement by direct tension, as is well known, it is difficult to so adjust the clamps as to obtain a direct and uniform pull, producing a good break. Another advantage of the transverse method is that, after having broken a prism of cement on the adopted span, one of the pieces and often both of them can be again broken upon a shorter span. To quote Mr. Morrison's language, "This would be an enormous advantage for the transverse method of testing, since from each prism we would get two, and often three, good tests instead of one doubtful one from each briquette broken by tension."

The apparatus required for transverse testing is simple. That used by Messrs. Abbott and Morrison was described in Engineering News of December 14, 1893.

In recommending this formula for transverse testing, I had intended to leave the value of S either to individual judgment or to the consensus of opinion as developed in the discussion which I trust these observations will lead to. But it has been suggested to me that my discussion and recommendations will be of greater value if I propose a minimum value of S for a good and reliable cement. I will, therefore, propose such values as seem to me to be reasonable and consistent, trusting that they will be critically discussed, and modified if thought advisable.

Cement is not a uniform material. Its strength, when tested, is found to vary greatly and will but roughly approximate any adopted standard. Portland cement is considerably

stronger than natural cement. Any cement is stronger when mixed neat than when mixed with sand. Cement which would be satisfactory for certain work might not prove satisfactory for work of a different nature. Moreover, it should always be remembered that the quality of the sand used, and the thoroughness and rapidity of manipulation, have about as much to do with the strength of the resulting mortar or concrete as has the quality of the cement.

I prefer American Portland cement; and for a good quality of work under ordinary conditions, have specified about as follows:

"The cement used will be, preferably, the best American Portland, well burned, heavy, and so finely ground that not more than 20 per cent. will be retained on a sieve having 10,000 meshes to the square inch (No. 100); when mixed neat, it shall show a minimum tensile strength of 100 pounds per square inch at the end of 24 hours and 300 pounds per square inch at the end of 7 days."

These requirements are at about the minimum tensile strength of neat Portland cement and are easily complied with.

In the report of a committee of the American Society of Civil Engineers, appointed to devise a uniform system for tests of hydraulic cement, read in January, 1885, the following were given as "The average minimum and maximum strength per square inch which some good cements have attained." Figures in parentheses are mine:

		American and Foreign Portland Cement.				American Natural Cement.			
		Neat.		1 part Cement 3 parts Sand.		Neat.		1 part Cement 1 part Sand.	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1 Day	1 hour, or until set, in air...	100	140			40	80		
	the rest of 24 hours in water	(110)				(50)			
1 Week	1 day in air	250	550	80	125	60	100	30	50
	6 days in water	(325)		(91¼)		(70)		(35)	
28 Days	1 day in air	350	700	100	200	100	150	50	80
	27 days in water	(437½)		(125)		(112½)		(57½)	
1 Year	1 day in air	450	800	200	350	300	400	200	300
	The remainder in water	(537½)		(237½)		(325)		(225)	

As the quality of the cements produced has somewhat improved during the ten years which have elapsed since this report was made, I think it will be not unreasonable to adopt, for a standard minimum strength in tests, values at one-fourth the range between minimum and maximum, above the minimum values given in this report. Such values of the tensile strength are written above in paretheses. Assuming these values for S and neglecting fractions in the results, the following values are obtained for the minimum center breaking weight, W:

TIME OF TEST.	PORTLAND CEMENT.				NATURAL CEMENT.			
	Neat.		1 part cement, 3 parts sand.		Neat.		1 part cement, 1 part sand.		1 part cement, 2 parts sand.	
	5 inch span pounds.	3 inch span pounds.	5 inch span pounds.	3 inch span pounds.	5 inch span pounds.	3 inch span pounds.	5 inch span pounds.	3 inch span pounds.	5 inch span pounds.	3 inch span pounds.
24 hour test	25	42			12	19				
7 day test	75	125	21	35	16	27	8	13	5	8
4 weeks test	101	168	29	48	26	43	13	22	8	13
1 year test	124	207	55	91	75	125	52	87	31	52

It will be noticed that I have added the values of W for 1 part natural cement to 2 parts sand, these being the proportions commonly used for this cement. From such data as are available, I infer that the strength of natural cement mortar mixed 1 part cement to 2 parts sand is about 60 per cent. of that of mortar mixed 1 part of the same cement to 1 part sand.

In selecting cement for masonry, the 24-hour test and the 7-day test are the only preliminary tests ordinarily available, although the 4-weeks test can usually be made during the progress of work.

While the above values proposed for the minimum per-permissible breaking weights in transverse tests, seem to be consistent and will probably serve as a reasonably reliable discriminating basis for indicating the quality of cements, it must be remembered that but comparatively little is known concerning this method of testing cement, and it is quite possible that these values may prove unsatisfactory. I would

recommend that a committee be appointed to investigate the subject and make a series of tests, reporting at the next annual meeting.

C. E. Greene.—I am not persuaded by the argument of Mr. La Rue, and see no propriety in introducing the symbol, r, as he does. Mr. L. C. Sabin, Assistant Engineer at U. S. Engr. Office, Sault Ste. Marie, has had wide experience in testing cement, and might speak with authority on this matter, as well as effect of freezing.

HIGHWAY BRIDGES IN THE MANUFACTURER'S HANDS.

DISCUSSION BY BENJ. F. LA RUE.

In Mr. Vedder's paper on the above subject, after mentioning the incompleteness of plans forming part of the usual contract for a highway bridge, especially with regard to matters of detail, he makes the statement that "To insure satisfaction in details, complete working drawings should form part of every contract, which should conform to safe standards and the finished bridge should always be subjected to tests with observations for deflection." This statement involves matters upon which there may exist some honest difference of opinion; they are of sufficient importance to be worthy of discussion.

For complete working drawings to be made a part of the contract, I do not think to be always either necessary or expedient. It is quite generally the practice for those submitting proposals for highway bridges to bid upon their own designs, the general features of which are shown upon what are commonly known as strain sheets. It would be neither just nor sensible to require all bidders to submit complete working drawing with their proposals. Nor would it be expedient, after receiving the bids, to delay making the contract until the favored bidder could make complete working drawings. Furthermore, I believe that it is safe to state that the average official who is intrusted with the purchasing of highway bridges would understand no more, if not actually less, from the working drawings than from such drawings as are commonly exhibited. I thoroughly recognize the vital importance of efficient constructive details, and I am also aware that the details of highway bridges are frequently slighted and are very commonly not what they should be. But I do not think that satisfactory details would be insured by including the working

drawings in the contract, though, possibly, such practice might tend to some improvement in the details. As noticed above, this practice, if rigidly followed, would involve some inconvenience.

But the contract should, at least, always stipulate that complete working drawings shall be submitted for approval and be approved, before actual work is commenced. These drawings should be submitted to an expert by the officials having the matter in charge; they should also be preserved as a record of the structure. In case of any failure of the structure or litigation concerning it, such drawings would be of value.

In this connection I cannot do better, perhaps, than to quote the words of Mr. Edwin Thacher in a written discussion appertaining to Mr. J. A. L. Waddell's General Specifications for Highway Bridges. Mr. Thacher's language is directly to the point, as follows:

"I would prefer to have general directions sufficient to insure a first class bridge and leave most of the details to the designer. * * * A simple strain sheet and specifications would be as satisfactory to an expert as anything further, and if not submitted to an expert, it matters little how much is shown. It should be sufficient if full detail drawings are submitted for approval before work is commenced. * * *

"Almost any of the specifications used by the bridge companies are safe enough, and those are the best which give the greatest strength for the least money. The trouble is not so much in the specifications as in seeing that they are faithfully carried out. This can be accomplished at a small expense by employing an expert of known ability to examine plans and strain sheets, and a competent inspector to examine sections, material and workmanship."

In cases where a consulting engineer is employed to make a complete design for the structure, with detail drawings, the complete drawings should form a part of the contract. And this is, without doubt, the best method of letting the contract for a bridge.

But where bidders are allowed to bid upon their own designs, (and this practice possesses certain advantages), I think the requirement that complete detail drawings shall be submitted and approved before work is commenced is a practicable requirement and productive of good results. This requirement, however, amounts to nothing, practically, unless the drawings are submitted to an expert. But this is, of course, simply another method of including the complete detail drawings in the contract, and perhaps Mr. Vedder intended that such liberal construction should be given to his statement.

I do not agree with the statement that, "The finished bridge should always be subjected to tests with observations for deflection." Such so-called tests are generally little more than farces, and, even when carried out in good faith, with careful observations for deflection, I doubt if the information thus obtained is of any real value.

In reference to this subject quite a controversy appeared in some of the German technical papers in 1892, the Centralblatt der Bauverwaltung taking the initiative. This journal held that "While unduly great deflection of a structure under a test load unquestionably demonstrates weakness, moderate deflection is no guarantee whatever of safety." In all material points this view is correct.

The deflection test will, to some extent, indicate the safety of the structure. It may be an evidence of the strength of the main members. It does not, however, to any appreciable extent, indicate the strength of the details; and the details are the parts to which the most critical inspection should be directed. For, when failure occurs in a bridge, it is usually in a detail. It may also be remarked that the calculations for theoretical deflection, depending upon a quite variable coefficient of elasticity, are not very reliable indications of what should be the actual deflection of a structure. For these reasons, it is my opinion that observations for deflection give very little valuable information concerning the actual strength of a structure.

But it may be pertinently remarked that it is easier to say that a thing is not good than to propose a satisfactory substi-

tute. And this applies with especial pertinence to the ordinary methods of letting the contracts for highway bridges. For, unsatisfactory as these methods are, it is difficult to suggest a more satisfactory substitute. It is extremely difficult to devise a plan by which the interests of a purchaser, who knows practically nothing about the article which he is buying, are to be protected in a contract. This is especially the case when the seller is exceedingly well posted in regard to the article. I confess that about the only way I know for such a purchaser to be protected, is for him to employ some one, who does understand the matter, to advise him.

But there appears to be a decided disinclination, on the part of the officials who purchase highway bridges, to employ a consulting engineer to advise them. This may be because they fail to appreciate the benefits to be derived from so doing, or, perhaps, it is because they think that it would be equivalent to tacitly admitting that they do not understand their business. Whatever the reason, the fact remains. An official once said to me that he wanted to be re-elected and was afraid that he could not be, if he spent money so unnecessarily. The bridge, he thought, would probably be good enough anyway. If officials will not employ consulting engineers to advise them in the purchase of metal bridges, I cannot see how the present system can be very much improved.

I will, however, suggest a very simple measure which, if practiced, would probably have some tendency to improve the character of bridge construction. It is to require a cast iron name plate to be attached to each structure, showing not only the name and address of the contracting firm and date of construction, as is common, but also the guaranteed capacity of the structure, and either stating the factor of safety, or, what is better, naming the specifications under which it is constructed. If then the contract is let to a responsible firm that is actually engaged in the business of manufacturing bridges, the effect of the guarantee will be wholesome and the resulting structure will very probably have a capacity reasonably near, if not equal, to its guaranteed capacity.

A responsible company, owning a plant and expecting to

continue in the business of manufacturing bridges, would not be apt to construct a bridge, having an actual capacity of not more than, say, 1,000 pounds per lineal foot and bearing the statement: "Guaranteed live load capacity, 1,800 pounds per lineal foot, according to Cooper's Highway Specifications."

For at any subsequent time, and especially in case of failure, an expert could be employed to ascertain the actual capacity of the structure, showing the variation, if any, from the guaranteed capacity. This, however, would not greatly affect scalpers and irresponsible bidders.

It might also be quite effectual to require the guaranteed minimum weight of the metal work of each structure to be stated in each bid, and, finally, in the contract. This would be of assistance in comparing the bids, and, when the metal work is received at the railway station, it would not be a difficult matter to have it carefully weighed, thus making any material shortage apparent.

AMATEUR PHOTOGRAPHING.

F. HODGMAN.

When I was in college the subject of photography came up in connection with other studies. We were taught the principles underlying the art and a little of the manipulations required. We had no camera, so could not manipulate that or prepare our plates. That part we learned at long range without doing it. We did go to town and get our negatives taken and printed as many pictures from them as we chose. We prepared our own albumen paper and went through the various processes, and a motley lot of pictures they were when we were done. Few of them have lasted till now, and it is a wonder that any of them have. Later I spent a year in Northern New Hampshire, where I was every day in plain sight of the inspiring scenery of the White and Franconia Mountains. One of my most intimate friends there was the photographer, Kilburn. I spent a good deal of time in his gallery and was much interested in his work. Kilburn and I used to discuss, time and again, the possibility of preparing a dry plate which could be used in making stereoscopic views, which were just then coming into fashion. We believed it would come some day, but that it would be less sensitive than the wet plate and so require a longer exposure to make a picture. This notion cost me at a later day the loss of a great many pictures that I would prize most highly if I had them. After I returned to Michigan, Kilburn went into the view business and made a large line of views that for clearness and beauty of finish I have never seen surpassed and seldom equalled. I worked for a time in a photograph gallery and became fairly well versed in the old wet plate process, in which the plates were exposed from ten seconds to two minutes to get a picture. A dozen years later, I was engaged as engineer in the location and construction of the Rio Grande Western Railroad, in Castle

Valley and Wasatch Mountains, of Utah. Naturally I wanted to preserve mementos of the wonderful scenery through which I was daily passing, and began by a feeble attempt at sketching. But I had not time for that, not being an adept at it. About this time dry plates had been made a success and cheap outfits advertised for sale. I sent for one which reached me after a long and, to me, very vexatious delay. When it came I found I had a 4x5 camera with a Waterbury lens,—about ten boxes of plates, as many packages of sensitized paper and such implements and chemicals as were necessary to make pictures on a very limited scale. There was also a little book of instructions. I looked it carefully through and found but little in it that I did not know already; not a word about the time of exposure, which I imagined should be two or three times as long as for a wet plate.

I had no dark room and but one plate holder (a double one) so for a time I was limited to the use of two plates a day. The first night after the outfit came, I loaded my plate holder and the next day exposed the plates, giving them from 15 to 30 seconds exposure. When night came again, I had my developer ready, lighted my little red lantern, put out all the other lights in the tent, and went to work with the whole party gathered around, deeply interested spectators. I took a plate out of the holder, put it right side up in the tray and flowed it with the developer. The image quickly appeared and the details came out in a very short time. When it was developed as much as I had been accustomed to, I washed it and put it into the fixing bath. It was a long time in clearing and when it was cleared and washed there did not seem to be anything left of it but a clear plate of glass with a faint image on it. Both plates turned out pretty nearly alike, and I concluded that the exposure had been too short. I was surprised to find that I could obtain prints from these negatives, in which, by a liberal use of my imagination and knowledge of the subject, I could trace most of the features of the landscape photographed.

As long as my plates lasted I got nearly the same results, and vary the time as I would, from 15 seconds to a minute, out

of over 100 exposures I did not get one good negative and not more than a dozen that could be called passable. Most of them faded away entirely in the clearing process, leaving nothing to print from.

On my way home I went into an artist's room in Salt Lake City and asked him what was the matter. He did not know. He had never seen a dry plate. At Chicago I attended a photographers' meeting, when I presented the case and was told that I had exposed my plates a great deal too long and developed them as much too short. Dry plates are very much quicker than wet plates, and the development must be carried on not only till the details can be seen on the face of the plate, but until the high lights can be plainly seen on the back. There is little danger of developing too much. Plates that would seem to be hopelessly fogged from over development will often come out clear and strong from the fixing bath.

With these hints in mind, I came home and tried again with better success and have been making photographs at odd times ever since. For five or six years I lost more than half the plates I exposed. Part of this came from inability to judge correctly of the time for exposure, but mainly from an error which it took me a long time to learn—namely, that I was using too old developer. I would make up a batch when I wanted it and keep what I did not use until the next time, which might be three days or three months hence. I know now that I lost more plates from using old developer than I did from bad timing, although as a rule I over timed my plates. When the image would not come out as it should I laid it to short exposure instead of poor developer, which was the true reason. After a time I got a 5x8 camera, with an extra pair of lenses for stereoscopic views.

For a few years past I have lost but few plates, except by duplication. I usually make two exposures, giving different times, as it doubles my chances of getting a good negative. One is always better than the other. It is a little annoying when you have made an exposure on a subject which you never can have another chance at, to find that it has not been timed aright.

Perhaps it will be well to trace our way through the various operations to be gone through in making a complete photograph.

The first thing to do is to get your camera. I find a 5x8 inch, with the extra lens for stereoscopic views, suits me the best. Get the best camera box and lenses that you can afford for the work you want to do. They can be had at all sorts of prices. Some of the cheap ones do pretty good work—better than you would expect from the price. I have thrown aside the tripod which came with my camera and use the tripod to my light mountain Gurley transit instead. It works as well for the camera as it does for the transit. Get as many plate holders as you have use for and can afford. If you are miles from home and come across something you want a picture of, it is very annoying not to have a plate left for the purpose. It is worse yet, if you happen to have one, to find when you come to develop it that it is wrong side up in the plate holder or that you have put it wrong side up in the developing tray and stuck it fast there.

You will soon learn that to ge the best picture a good deal depends on the point of view, and a great deal on the strength of the light and the direction from which it strikes your subject.

In out of door work you cannot arrange these things to suit yourself as you might in a gallery. You must select a point for your camera which will give the most pleasing view of your subject—or such a view as you want of it—and then watch for the time when the light is such as will best bring out its pleasing features. Sometimes you will have to get up pretty early in the morning for it. A person wants the soul and training of an artist to get the best results.

If you are making pictures right along you will be able to judge very closely how long to expose a plate and will not lose many from that cause. If you only take it up at long intervals, you will not be so sure of it. The plate makers say you should use a slow plate for out of door work, as it gives more latitude in the exposure without effecting the result seriously. I like better to use a quick plate, and get the same

result by stopping down my lens by using a diaphragm having the smallest practicable opening. With my cheap lens I get greater depth of focus and sharp outlines clear to the edge of the picture. With my lens thus stopped down I expose a No. 26 Seed plate from half a second to three seconds or more, according to the light. I have no shutter and guess at the time. At this point a good many amateurs stop business and hire a photographer to do the rest. I believe that every civil engineer should have a camera and know how to use it, and how to do everything connected with it, from loading the plate holder to mounting the print. When I built my office I put in a dark room. Before that I did all work, which required it, in the night by the light of a lantern with a red globe. That worked all right and does yet.

I have tried about the whole range of developers from oxalate of iron to eikonogen, with varied success, but the one developer which I always depend on is a pyro developer prepared from a formula which was published in the Scientific American some years since. It was such an easy formula to remember that I took to it at once. It is:

Bromide of Potassium,	1 grain	No. 1.
Pyrogallic Acid,	2 "	
Oxalic Acid,	3 "	
Water,	1 ounce	
Sal Soda, 50 grains		No. 2.
Water, 1 ounce		

Use equal parts of Nos. 1 and 2.

No. 1 should be used fresh or within a week or two after it is prepared. I have had good luck with some that was several months old by adding a little pyro to it. No. 2 will keep good till it is used up. I use about two ounces each of Nos. 1 and 2 to develop a 5x8 plate. If I have two plates to develop, I use the same developer for both, but do not like to use it longer as it gets too dark colored and stains the film too much. It gives the plate a reddish brown tint, which retards printing. For a thin, weak negative this is an advantage, as it will often make a good negative out of what would otherwise be a poor one, the effect being the same as an intensifier.

To develop a plate, take it in your dark room, if you have one, or at night by your red light. White light should never be permitted to touch a plate, except in the camera at the time of taking the picture, until development is well along or completed. Of course, your stock solutions Nos. 1 and 2 are already prepared. Take a sufficient quantity of each, mixing them well just before using. Put the plate film side up in the tray. If the plate gets wrong side up it is a goner. Pour the developer quickly and evenly over it, wetting the entire film at once. If this is not done you are liable to lose the plate by unequal development.

If everything is right the image will begin to show within a minute. If your room or developer is cold, do not be discouraged if it is a long time showing up. It may prove a good negative, but will take longer to develop. If the image flashes up very quickly, the exposure has been too long. After the film has been well wetted, the developer may be poured off and on, occasionally, to good advantage, as it seems to develop better when the film is in contact with the air, without any developer on it save what adheres to it. Continue the development until the main features of the image can be seen on the back of the film by reflected light. Then put the plate in clean water to wash off the developer, and from that into the fixing bath, which is made by d ssolving hypo sulphide of soda in water at the rate of about one ounce of hypo to four ounces of water. Let the plate stay in the fixing bath until you can see no traces of the white film when you look at the back of the plate—and a little longer. Then wash it in a dozen or so changes of clean water. I find that I get quicker and better results washing negatives, and prints too, by putting them in trays and changing the water on them every few minutes, than I do by letting a stream of water flow over them. The diffusion process is decidedly the quickest and does the best work. The hypo must be all washed out of the film or it will spoil the negative sooner or later, as well as damage the prints. When thoroughly washed, set the negatives up in a rack edgewise to dry. They must take their time for it without being heated. They will not stand heating over a stove as the old

collodion films would. It used to be the fashion to varnish the negatives when dry, and it is a nice little trick to do it well and not leave wrinkles. I can not discover that it pays me to do it. It certainly does not improve the printing qualities of the negative, although it may its durability.

Next comes the printing, and for this you must have printing frames to hold your negatives and sensitized paper to print on. There are many brands of paper on the market. They belong principally to three groups, the albumen paper, the gelatine paper, and the collodion paper, so called from the substances employed to coat the face of the paper for sensitizing. The latter varieties are sold in packages ready sensitized, any size you need, and all you have to do is to put your negative in the printing frame, film side up, then put a piece of the paper on it, film side down, clamp it in place and expose it to the sunlight a sufficient length of time. How long that will be depends on a variety of things, the negative, the strength of the light and the kind of paper. Generally speaking, they should be printed darker than they are to be when finished, as the tendency is to bleach out in the finishing. Some of the gelatine papers darken a good deal in the final drying after washing and will not bear so dark printing as others. If your negative is very thin, with plenty of detail, you will get a better and stronger picture to print it in the shade. Print from a dense negative in the direct sunlight. Do not expose the sensitized paper or the prints to the open daylight any more than is absolutely necessary, until they are toned and fixed. It makes all the difference between a clear, bright print and a dark, muddy one, whether you observe this or not. When you have a thin negative you can get a better print from gelatine paper than you can from albumen paper. Prints on gelatine paper are very fine when first finished. I am somewhat skeptical in regard to their durability.

Printing done, the prints are trimmed to the proper size for mounting. I use a sharp knife for this and glass patterns which I cut out myself. I find a sheet of pasteboard is a pretty good thing to lay prints on to trim them. When trimmed, put them in a dish of clean water, one at a time, face

downward, pressing them down under water as you put them in. You must have clean hands—clean trays and clean water for this, (soft water preferred) and no matter how clean your hands are, you should *never* put your fingers on the face of a photograph, either before or after it is finished. It is as certain to soil it as it would polished silver, and you can never remove the effects of it Collodion paper is not so easily soiled as the other papers. When your prints are well soaked take them out one by one and put them into a fresh dish of water and in that way wash them through half a dozen waters. If you are using hard water, the silver salt, as it is washed out of the paper, gives the water a milky color. Wash till all traces of it are gone. If you are using gelatine paper, the water should be cold, and in summer you may need to use ice to keep it cold enough not to dissolve the gelatine film. With collodion paper you can use warm water.

Toning is the next step. To do this put them in a bath containing chloride of gold. There are numerous formulas for the toning bath, as there is for everything else connected with the work, but I have succeeded best in this way: I dissolve a 15 grain bottle of gold chloride in four ounces of water, which I keep in a bottle for use as I want it. For toning I put enough water in my toning dish to nicely cover half a dozen 5x8 prints and give them a chance to float about in it. Then I put in enough of the gold solution to give the water a slightly yellowish tinge. It will not take much for that. Then I add a pinch of bicarbonate of soda, enough to make the bath distinctly alkaline. Put a few prints at a time into the toning bath, face down, and keep them moving or they will not tone evenly. Neither will they if not well washed beforehand. Keep watch of the prints and when they have attained the right shade and the details are well brought out, remove them to a dish of clean water. If you get a good tone, there must be a good strong print to start with—something for the gold to take to. You can't get a good tone on a thin, weak print.

The prints go next to the fixing bath, which consists of one ounce of hypo sulphite of soda to about 16 ounces of water and enough bicarbonate of soda to neutralize any acidity

of the bath—say half a teaspoonful. Put the prints in, face downward, and keep them moving so they will not pack together, and thus keep the hypo from getting at them. Fifteen minutes is about the right time for fixing. Then wash them, as directed before, through fifteen or twenty changes of water, letting them stay in each water from three to five minutes. When washed thoroughly they are ready for mounting.

Take them out of the water and pile them up, face downward, on a piece of smooth, clean oilcloth. Lay a piece of heavy blotting paper on top and squeeze or press the water out of them. You are supposed to have your cards ready for mounting, and some smooth, clean paste, free from grit or hard specks. Brush the paste smoothly over the back of the print, being sure to leave no part unpasted. Lift it carefully from the pile and place it on the card. Put another piece of clean, smooth oilcloth on top of the print, to keep your hands off from it, and then rub it down smooth and lay the picture aside to dry. If you are using gelatine paper, do not pile the pictures up after mounting or allow anything to touch the face of the picture while it is drying, or it will be glued fast.

THE HOLLY DRIVING TRACK.

GEO. W. DOANE.

The laying out and construction of a driving track is a subject in which we, as surveyors, are more or less interested, and one upon which very little has been written by surveyors and engineers.

It will be conceded that the best track for speed is a perfectly straight, level track; but, of course, this style of track is subject to the objection that the time cannot be noted by the same person, hence it is necessary to have a track on which the horses can start and finish at the same place.

The rules of both the American and National Trotting Associations require a track to be one mile in length, three feet from the pole. There are no regulations in regard to shape. On what is known as a regulation mile track, the stretches and turns are equal in length; that is, 1,320 feet each.

In the construction of a regulation mile track 66 feet wide, it will require a rectangular area of about 52.5 acres, and for a half-mile track 50 feet wide, it will require a rectangular area of about 10.75 acres, exclusive of ground for grand stand, stables, etc.

The surface area of a mile track 66 feet wide is about 8.3 acres. The surface area of a half-mile track 50 feet wide is about 3.2 acres, or less than 40 per cent. of area of a mile track.

It will be seen that the half-mile track can be built for much less cost than the mile track and hence its desirability for small towns.

In a race against time, the mile track has the advantage in longer turns, and requiring less elevation than the half-mile track, to attain the same speed. On the other hand the half-mile track is liked better by some because they can see the horses start and finish, and also pass the grand stand in the middle of the race.

In the spring of 1893 I was called upon to lay out and construct a half-mile driving track for the Holly Driving Club.

After making inquiry and visiting a couple of tracks and examining the ground upon which the track was to be located, I recommended a track with two parallel tangents 600 feet in length and a semicircular arc of 720 feet at each end, and having a radius of 229.2 feet to the half-mile line, and 50 feet width of track; which plan was accepted by the club.

The track was located on a piece of ground containing 26 acres, about one-half mile northwest of the village of Holly, and between the Shiawassee river and Bevins lake, on a slight ridge. The track was located lengthwise of this ridge. The soil, except the north turn, which was a light sand, was a gravelly loam which made a very good track, but the north turn had to be dressed with heavier soil.

The system adopted in laying out the track was as follows: After some preliminary measurements, two hubs 3x3 and three feet in length were driven to the surface of the ground and a wire nail driven in each at the exact point of the center 600 feet apart. The tangents were located by placing a transit over one hub and exactly perpendicular to the line joining the two center hubs and measuring 226.2 feet for inside, and 276.2 feet for outside tangents. Stakes were then set ten degrees apart on the turns by angles taken at the center, making them 39.47 feet apart on the inside, and 48.2 feet apart on the outside of the track. We then went through the same procedure at the other turn.

Stakes were then set on the tangents 50 feet apart and numbered.

Then we were ready to take the levels, which we did by placing the level in the middle of the ground and taking a reading at each of the stakes; making benches of the two center hubs so that any stake that might be lost could be easily relocated from the center hubs. After which a profile was made and a grade established.

Owing to the unevenness of the surface of the ground, we found it necessary to make a grade, on the inside, of 15 feet for the first half length of the track and the same on the

return. This is, perhaps, more grade than is desirable, but owing to the extra cost in building a level track, this was thought best.

The outside of the track was raised six inches higher than the inside on the stretches, to give drainage, and forty-eight inches higher on the turns.

On the outside the rise was begun at a point 50 feet from the turn, on the stretches, and carried with a true grade until it was full height at 50 feet past the turn on the curves.

The drainage of the track was comparatively easy. A six inch tile was laid from the low lands on the west side of the grounds, and was laid across the track at the southwest turn, where a catch-water basin was put in to receive the water from the open drains laid along the inside of the track; and from there a three inch tile was laid across the grounds to the east turn to receive the water from the open ditch along the track.

The earth was moved with wheel scrapers on the longer hauls and drag scrapers on the short ones.

The cuts nearly made the fills at the south end, and surface soil was taken from the inside of the track to complete them. At the north turn the earth that was not used in making the fill was wasted, as it was too far to haul to where it was needed and unfit for track surface. The north turn was covered with surface soil from the south end of ground.

The track was packed and leveled by the use of a harrow and float. The float was made of eight pieces of 2x4 scantling bolted together so as to form a float sixteen feet square which was drawn by four horses.

We first tried a road grader for leveling the track, but its use was very unsatisfactory and was abandoned.

After the track was thoroughly leveled and packed down, the small stone were raked off by hand with fine tooth rakes prepared for that purpose.

The inside fence was then built by setting posts eight feet apart and about forty inches high, with a guard board ten inches wide, nailed on about twenty-three inches above the ground, and a 2x4 scantling spiked to the top of posts. We then carefully measured the fence with a 100-foot steel tape,

along the guard board. Each tangent 600 feet, the south turn 710.57 feet, and the north turn 710.6 feet, making a total length at the fence of 2,721.17 feet. Add to this 18.85 feet for the length of the half mile line three feet from fence and we have 2,640.02 feet for the length of track.

The judges' stand was placed on the stretch 100 feet from the southwest turn.

The cost of track and buildings is about as follows:

26 acres of land at $50	$1,300
Grading and ditching	600
Judges' and grand stand	426
50 stables at $12	600
Total	$2,925

There has been expended since completion about $300 in top dressing with clay loam.

The track has given good satisfaction to the club and is highly spoken of by horsemen.

Q. Do you know whether any of these associations have by resolution, or otherwise, fixed the maximum grade?

A. I believe there is nothing said in regard to grade of tracks.

Mr. Doane.—I don't know as there is any fixed rule, but it is a recognized rule among horsemen that the road shall rise one inch to the foot; a track is not disqualified, no matter what the shape is, provided it is not too short.

Mr. Rogers.—I don't know whether other people have had the experience we had at Port Huron. Last year I was called upon to reduce the elevations on a track which had been satisfactory; they said the reason for reducing the elevations was on account of the use of pneumatic tires on the sulkey. I did not lay out the track, but the elevation was one in ten before it was reduced, and it was cut down so that the elevation was not more than a quarter of that.

Mr. Doane.—I corresponded with the Secretary of the Detroit Driving Club. He said they had built a track there with tangents; I suppose they used the easement curve, and he said they used an elevation of one inch in twelve.

Mr.————.—The Terre Haute track is what might be termed a square track. There are four straight stretches, and the curves are divided into four parts, and it is one of the fastest tracks in the United States.

Q. Do you know the radius of the curve?

A. I don't know, but about the same as in a half-mile track. It is a mile track divided into four straight stretches. The theory is that the straight stretches change the gait of the horse slightly and it gives him a rest; while he passes the curve he is only there a short time until he is on the straight stretch. It gives him four changes in going around,—whereas the long curve only gives him two.

WHAT CAN BE DONE WITH THE WASTE PRODUCTS OF OUR LUMBER WOODS.

J. J. HUBBELL.

The lumbermen of Michigan purchase their timber by the tract or group. It is true the location is indicated by certain description of land, but the land itself is a very small factor in the transaction, the timber is what the lumberman purchases, and when he is ready to cut the same, he cnters upon the lands and cuts, carries away, and converts to his own use, as much of the timber as he thinks he can handle with profit; the remainder of the timber is left standing or lying upon the ground, and it is this remainder which is allowed to go to waste to which I wish to call your attention at this time.

A personal examination of cut lands in Michigan will reveal the fact that a very large percentage of the timber is allowed to go to waste. I am satisfied that in the cutting of pine timber this waste will amount to 40 per cent. of the original forest growth, there being usually a considerable amount of beech and other hard woods, as well as hemlock and cedar, mixed with the pine, a large proportion of which is never cut. I am also satisfied that the proportion of waste in the cutting of hemlock and hard woods will amount to nearly if not quite 60 per cent. of the original forest growth, and that, as a whole, in the cutting of timber in Michigan the amount taken away, and made use of, does not exceed one-half of the amount originally standing upon the lands.

This timber that is left consists largely of beech (of which at the present time very little use is made), also maple, elm, birch, black ash, cedar and hemlock, which, for reasons that it will not float, or it is too expensive to get it out of the swamps, or for some other reason, cannot be handled with profit; also defective trees, dead stumps, tops and limbs.

It requires some figures to call to our minds an approximate idea of the vast amount of this waste product. I have not been able to secure close estimates of the amount of timber cut in the State of Michigan annually, but from what data I have been able to secure, I have estimated that it amounts to 1,200,000,000 feet (board measure) of pine, 400,000,000 of hemlock, and 400,000,000 feet of hard woods, making a total of 2,000,000,000 feet. I am also satisfied that the way logs are scaled in Michigan, one thousand feet of logs will make one cord of wood. If this is true, we leave standing and lying upon the ground to go to waste yearly, the enormous amount of timber sufficient to make over 2,000,000 cords of wood. Commence piling this wood upon the Atlantic Coast in the State of New Jersey and pile westward one cord high in a continuous rank, and it would reach across the State of New Jersey, across the State of Pennsylvania, also Ohio, Indiana, Illinois, Iowa, Nebraska, Colorado, Utah, Nevada, in fact, well nigh or quite to the Pacific Ocean, in other words, two million cords of wood will make a continuous rank over three thousand miles long. As compared with coal, if we allow three cords of soft wood, or two cords of hard wood, as equal to one ton of coal, we have the fuel value of this waste product equal to 733,000 tons of coal. The money value of this waste product computed in wood at $1.00 per cord, or in coal at $3.00 per ton, we find to be over two million dollars.

I am aware that these figures will seem to many of you as exaggerated, but I only invite you to figure the problem for yourselves, and whether your computations fully corrobate my figures or not, you will arrive at a result which will satisfy you that there is an enormous waste of material going on at the present time in the State of Michigan.

What becomes of this waste product? In some sections there is an effort made to get out a small quantity of cord wood, there are a few coal kilns scattered throughout the State, but all the wood manufactured from this product is an insignificant amount compared with the total waste. The great mass of this timber left standing and lying upon the ground is destroyed by fires, and the burning of the same is

usually left to chance. The fires usually take place in time of drouth, and not only destroy the waste product, but often do great damage to the uncut timber standing adjacent, and also to farm and village settlements throughout the northern part of the State. The first fire of a chopping not only burns the brush and tops of the cut timber but also kills the remaining standing timber, also the young second growth timber with which nature attempts to re-clothe the ground. This dead timber in time blows down, the dead underbrush and limbs of the fallen timber make kindlings and fuel for a second fire, which is frequently followed by a third, and sometimes a fourth burning. These repeated burnings, usually occurring at times of drouth and extending over a period of eight or ten years after the original chopping, result in leaving the land in a most deplorable and desolate condition, the leaf mold and soil itself being largely consumed, the fires enter the swamps and burn their way several feet in depth into the dry, mucky soil, all second growth of timber is repeatedly killed. In addition to this, the ground being bare and exposed, evaporation is largely increased, and the effect upon the moisture and rainfall is evident from the greatly diminished flow of water in our rivers and the lowering of the surfaces of our great lakes. So we see that the loss of so large a percentage of our forest growth is only the beginning of loss, incident to our present method of lumbering and the neglect of the care of the waste product.

From a legal standpoint of view, there is no question but that lumbermen have a right to cut and use as much of their timber as they please, and to leave for destruction as much as they see fit, but when viewed from an economical or a moral point of view, grave questions arise as to the right of any class of men to entail such waste and desolation upon the land and the future prosperity of the people and State. Older countries than ours have long since learned the evil of permitting the indiscriminate destruction of their forests and strict laws regulate the cutting of timber, and provide for the perpetuation of suitable forest growth. The indifference of the American people upon this question I attribute largely to the fact

that from the first settlement of the country until the vast prairies of the west were reached our forefathers were confronted with a dense forest growth, which stood in the way of the improvement and cultivation of the land, and we have waged for generations a relentless war with axe and torch upon our virgin forests until we have well nigh lost all our respect or reverence for a healthy forest growth which it has taken nature a century or two to perfect. I apprehend it will take a considerable time, a long and earnest effort upon the part of economists, before the American people will recover from their present apathy and indifference upon this subject. But, to return to my topic, what can be done with this waste product? The first answer would naturally be that the lumbermen should be compelled to take care of it, and yet I apprehend that any steps taken in this direction must be well considered and that radical measures would be disastrous to the best interests of our state and our people. Our lumbering interest is one of the greatest, our lumbermen the most enterprising of our citizens; they give employment to an army of men; they are conducting their business in compliance with the laws of trade and of supply and demand. They are no more vandals, or more selfish than other men; they are deeply interested in the preservation of our forest; it is largely their property and their future stock in trade; they are interested in preserving the fertility of the soil; it is their land after being cut over and if they ever realize anything for it, it will be on account of its value for agricultural purposes; they are interested in securing a second growth of timber, and maintaining the waters of our rivers and lakes, they are their principle means of transportation; no class of men are better acquainted with the evils of which I speak than they, and I am satisfied that as a class they will heartily join in any practicable measures to remedy the same, a large proportion of them, however, are carrying on business upon a very small margin of profit. While it is true that certain older operators may have purchased their timber at a nominal value, a large proportion of the present lumbermen have paid full value for the timber, expecting to cut and market the same without being put to undue expense other

than that which is usually incurred in lumbering operations, and any steps taken in the direction of compelling them to take care of this waste product must be reasonable and well considered. If the process of destroying by fire is to be continued I wish to suggest;

First—That the lumberman be required to cut down all of the timber upon his cut lands. This can be done at the time, soon after the merchantable timber is cut at a small expense. To leave this timber standing is not to save it, it eventually falls a prey to the fires, but if cut in the first instance it would have a tendency to make a more thorough work of the first fire and put a stop to the second, third and fourth burnings.

The second suggestion that I would make, is that all choppings should be burned over the first spring after cutting, during the month of May. It is well known that at this time of year, before the green forest growth begins, fires burn readily, at the same time they do not burn deep, and do not enter the swamps and mucky ground. Fires at this time of the year do but little damage to the surrounding timber and seldom are destructive to farm and village settlements. If all the timber was cut down and choppings burned at this time of the year, there would be but little danger of subsequent fires, and in most instances the second growth of timber would be unmolested and have an opportunity to reproduce a second forest growth. Whether this annual burning should be left to the lumbermen to do under penalties, or whether it should be done by township or county officials, is a question for future consideration, but is it necessary to continue this destruction by fire? As engineers, I would say that it should be our aim to utilize and make use of this waste product, rather than to attempt by legislative enactment to direct and control its destruction; as engineers we should exert ourselves to save this vast amount of timber which is at the present time going to waste, to provide for better and cheaper means of transportation, to encourage the use of wood as fuel, to devise improved methods of handling wood, manufacturing charcoal, wood alcohol, paper pulp, and other products, anything to make a profitable use of this material rather than waste and destroy it.

The waste materials of other productive industries have often been found to be valuable and to add material profits to the industry. It was finally discovered that the despised and troublesome cotton seed contained oil as palatable and nutritious as the olive. Our timber going to waste contains potash, creosote, wood alcohol; it contains light, heat and power, all of which have a commercial value in the world; we should endeavor to devise ways and means whereby they can be made available for the use of mankind, and then we shall no longer be troubled with the question as to what to do with the waste product of our lumber woods.

Mr. Hodgman.—It is a paper that does not leave very much room for discussion, except to endorse what the gentleman has said. He has opened up a very important subject—one of the most important that we find to consider, but I don't know what we can do except to go at it and educate the people, and do the best we can.

The President.—Mr. Hubbell, is it not a fact that where pine timber grows mixed, or where it grows of such size that part of it is left for a future harvest, if the cutting away of a mass of that timber and allowing the sun to come in and evaporate the moisture which was before held in the leaves and twigs and earth, if the pine timber which is left is not likely to die for want of water, even where the rainfall is ordinarily good?

A I think pine is one of the best timbers to partially cut and partially leave, if you can only keep the fire out. Pine trees almost entirely isolated will live and grow. It is not so with hemlock; that will die, but with pine timber which has been partially cut, it is not the question of drouth, but the fire which almost inevitably comes in and kills it.

The President.—I have made one or two trips from Michigan to the Atlantic coast, at some expense, to fight wood creosote, and there is this important point about creosote which Mr. Hubbell has mentioned. Creosote does exist in wood, and in coal, which is a geological formation of wood; it has been found that creosote obtained from the distillation of wood is largely impregnated with acetic acid. In the use of

creosote from wood in preserving timber, it has been found that where it comes in contact with metals, that the acetic acid with which it is impregnated, will attack and destroy the metal and cause much damage. It treating timber that ought to be remembered, because it has involved a great deal of loss.

Mr. June.—I would like to ask if Mr. Hubbell has ever had any experience in measuring the per cent. of value in the growth of pine timber?

Mr. Hubbell.—No, I have never figured it out; I know in a healthy pine growth, it is pretty well established that the growth will keep ahead of 6% interest and ordinary taxes, but if your timber gets burned off, you are of course a loser.

Mr. June.—I was talking once with Mr. Farrell, who has some interests down south. He says that the pines are not as good as in Michigan, but he thought the growth there was as good as 10%. Mr. Webster of this city had some trees up at Gladwin, which he measured and watched, and he made the statement that they were as good as 10%.

Mr. Hubbell.—In that connection, of course, you have got to figure 10% on what you have to pay for the timber. In Michigan, at the present time, pine stumpage has come to such a point that it would take pretty good pine to come up to that.

Mr. June.—The trees that I speak of, were trees that were left, and a second cutting.

Mr. Appleton.—If the members wish to pursue the subject of forestry, I have found that the agricultural department at Washington publish a report, by Mr. B. C. Furnow, Chief of the Forestry Division, which can be had for the asking. Mr. Furnow is an enthusiast on this subject.

The members will find a great deal of valuable information in that. The State Department also publishes a special Consular Report on Highways in Foreign countries, which bears on this subject, and besides gives very complete specifications of various methods of constructing highways in Europe, and, proud as we are of our Yankee accomplishments, we must bow to our European brothers in the construction of highways, and much valuable information can be had from them.

IMPROVEMENT WORK ON THE ANN ARBOR RAILROAD.

BY MR. RIGGS.

I wish to state that in writing to the secretary and notifying him that I would give a paper, I tied a string to my letter and said I would do so provided I could find the time. As most of you are well aware, I am severing my connection with the road, and opening a business, and for the past sixty days I have hardly seen home, so that you will have to bear with a few very rough notes, and I will merely outline what work the T. & A. road has done and invite a full discussion.

I believe that possibly better results can be reached by answering questions than by undertaking to give any lengthy paper.

The problem of Railroad Construction will in the future occupy much less of the attention of the Engineering profession than in the past, while the question of economical maintainance, and of construction of old lines, placing them on a basis where they can be economically operated, will demand more attention.

The tendency of the times is toward a greater amount of legislation on the railroad question. Legislation and competition, with a number of other causes, are constantly working to lower the rates of freight, that sadly cuts the revenues.

The smaller lines of railroad throughout the country were built frequently on limited means, and without particular attention to economy in grades or curvation; often were constructed to take care of a limited local traffic, but by extensions undreamed of by the original projectors, or by connection, were forced to handle a much greater volume of business than was calculated upon.

Such lines of road, when brought face to face with the problems of reduced rates and decreased earnings, must meet

the question of either increased power, reconstruction on more economical lines, or must admit failure and cease to operate.

Larger and more powerful locomotives have been tried. For a poor road that means an immense increase in the wear and tear of all track structures and the ultimate reconstruction on a heavier and more substantial scale.

Still, other lines have retained the old class of power, and by reducing grades, have increased the hauling capacity of their trains.

Perhaps no line in the State of Michigan better illustrates the class of road referred to than the Ann Arbor Railroad, formerly known as the Toledo, Ann Arbor and Northern Michigan Railway. It was built under the most discouraging difficulties, without money; simply on wind. Its projector had at all times faith that he could push it across the state and make a good road of it, and after years of work he has done so.

No definite plan was worked out before construction was commenced. The road started at Toledo, and went northwest. It was a local road, pure and simple, for years. The North end was constructed cheaply as possible, to handle the lumber traffic of a practically limited territory.

A dozen different engineers located various short sections; nearly as many small companies contributed to build it. Old grades were utilized, abandoned logging roads were seized upon and used for miles; when any considerable length of line was to be built, it was generally undertaken with a small supply of cash and a large supply of courage; grades were changed to reduce the amount of yardage, and every expedient adopted that would permit the company to operate trains in season to secure bonds.

In 1892, the ferry line across Lake Michigan was put in operation; from a local road it became a through freight line, and was forced to compete for traffic with older and better located roads.

At this time its grades were exceedingly heavy (nine loaded cars being all that could be carried at several points); its track was bad by reason of poor ties and no ballast; its bridges old and poor, and the road was in generally bad condition.

A general plan of improvement was decided upon and has been carried out nearly to completion.

This plan has involved the expenditure of a large amount of money and an immense amount of work. It is not my intention to do more than roughly outline the work which has been done and call attention to a few statistics of steam shovel work, which appear to me to be of great interest to Engineers, who will, in the future, be called upon to undertake work of a like character.

In the matter of bridges, the company has a large number of pile trestles and comparatively few permanent structures. The work of filling or renewing has been carried on with the following result:

28 new bridges have been built as follows:—

2656 lineal feet of deck plate girder; 190 feet of three plate girder; 115 feet of steel deck truss and three 20 feet I beam spans, or a total of 2906 feet of permanent opening established.

On all of this work, excepting that done prior to 1894, (or on about 90%) a load has been specified as Cooper's Class Extra heavy A, with impact of 25% on spans of 20 feet, and less, decreasing at a rate of 1% per four feet of increased length.

116 bridges have been filled and 12 have been shortened—a total opening abolished of 5796 feet. Cast iron pipe has been used largely, and for smaller openings, Blackmer and Post's double strength culvert pipe has been used. In marshy or treacherous bottoms a floor of grillage has been constructed as foundation for pipe culverts.

Concrete piers encased in steel cylinders have been put in River Raisin bridge at Dundee.

The bridging is in safe condition and all of the larger permanent openings are built so that it is safe to say that 75% of the superstructure work is done.

The foundations so far have generally been piling, but in every case the future masonry pier or abutment has been figured on, and a sufficient number of piles driven for a foundation for this work.

A comparatively small amount of work was required on buildings. The station buildings being generally in good condition; four new round houses and a few stations rebuilt being the principal work.

Yard room was greatly increased by the construction of complete and well arranged division yards at Toledo, Durand, Mt. Pleasant, Cadillac and Frankfort, and by the construction of a considerable mileage of additional sidetracks at other stations. This work has greatly facilitated the handling of traffic.

A large amount of work has been done in the way of eliminating curvature or grades by changes of line.

The most important work of this class has been done in Clare County, where for several miles an old logging road was used. Some six miles of entire new line eliminates over 200° of curvature as well as reduce a heavy southbound grade from 2% to 0.75%. Other minor changes have been made, aggregating some five miles in distance and greatly reducing curvature.

The most important work of this sort is the contemplated change of line north of Ann Arbor, which will abandon ten miles of line. The original intention was to build a road from Ann Arbor, via South Lyons and Pontiac to the north. After a part of this had been built, a branch was constructed from Emery, seven miles from Ann Arbor, to Whitmore Lake and Hamburg. The line to South Lyons was subsequently abandoned, and the branch is now main line.

The new line has the following characteristics:—

It saves 2.382 miles in distance.

It saves 244° 46′ of curvature.

It saves 1.57 miles of actual curved line.

It has a north bound rise of 155 feet, as against 245 on the old line, saving 90 feet.

It has a south bound rise of 48 feet, as against 138 on the old line, saving 90 feet.

It has 15,500 feet of 0.75% (40 feet) maximum grade, as against 19,300 feet of 1% and over in the old line, with a maximum of 1.5%.

It has 4,600 feet of 0.75% (30 feet) maximum south bound grade, as against 10,100 feet of over 0.75%, with a maximum of 2% on the old line.

This line will probably be built during the present season, and will greatly improve the road in its ability to handle north bound business as well as greatly increase the safety of the line.

By far the larger part of the work done during the past three years has been toward establishing a uniform system of grades. An outline of the plan, and the submission of a few figures is all that can be done.

The new scheme contemplates grades as follows:—

North bound maximum grades—Toledo to Clare, 20 feet per mile, except at Milan, where trains will double 1 mile, and at Ann Arbor, where a pusher will be maintained. Clare to Frankfort, 52$\frac{8}{10}$ feet per mile.

South bound maximum grades—Frankfort to Cadillac, 65 feet per mile. Cadillac to Clare, 40 feet per mile. Clare to Toledo, 30 feet per mile.

Next season's work will complete all work on this plan except possibly one or two south bound grades between Cadillac and Frankfort. All of this work has been done by the company. They have used steam shovels of various patterns, all having 1½ yard dipper, and having used Barnhart Center Unloaders, plowing with engine.

The past season has been one of greatest activity, six shovels being at work, and for a greater part of the time we have worked both day and night shifts.

This fact has rather impaired the value of our statistics, as all of our measurements are based on actual pit cross sections, and it was absolutely impossible to separate day and night work. In making up the statement, a night's work is counted as a day, thus affecting the average hourly output of the shovel. Another feature of uncertainty is the fact that the number of locomotives in attendance on the shovels varied from time to time, and the record of such movements was very difficult to keep.

The additional fact that no form of report was used, all data being compiled from daily telegraphic reports, made it impossible to secure as complete a record as was desired.

With this general outline I would submit the table of cost. All figures represent cost of earth under the track, including all labor of shovel crew, train crew and track men, fuel and supplies, but do not include any figures for rental of plant, repairs or any charges for service of telegraph, station or other employees; nor do they include engineering or superintendence (other than foreman).

It is to be regretted that there is not more literature on Steam Shovel work, the work of Mr. E. A. Herrmann, in *Engineering News*, some two years ago, being the most complete discussion I have seen. Records of cost of such work, however, are rare, and these are the most valuable information that can be had, for anyone about to begin work of this nature.

The Steam Shovel and its relation to railroad reconstruction has been but little discussed. This machine has a great future of usefulness in the work of railroads, as will be seen by the work done on the Ann Arbor Railroad.

ANN ARBOR R. R. Steam Shovel Exhibit, Season of 1895.

LOCATION AND DATE.	Total Car Loads	Total Cu. yds	Averge yds. per car.	Total Days.	Averge Car'ds per day	Averge Cu. yds per day	Actual Time of Shovel hrs	Averge Loads p. hour	Averge Cu. yds p. hour	TOTAL COST.	Cost per yd. Under Track.	Character of Material.	REMARKS.
SHOVEL No. 1 (BUCYRUS S. S.)													
Millersville ..... April 3 to June 20	6676	55984	8.37	68	98.19	822.56	.....	.....	.....	$5509 59	$0.0984	Sand	.....
Harrietta ..... June 20 to July 13	2164	20017	9.25	19	113.90	1053.52	.....	.....	.....	1773 35	.0886	Sand	.....
Pittsfield ..... July 15 to Aug. 31	4913	32928	6.70	59	83.27	558.10	.....	.....	.....	4377 61	.1331	Clay	.....
Ann Arbor ..... Sept. 2 to Sept. 29	2362	16910	7.16	46	51.35	367.61	.....	.....	.....	3355 64	.1981	Gravel	Long Haul.
Milan ..... Sept. 30 to Oct. 24	2490	23527	9.45	44	56.60	534.70	.....	.....	.....	3266 29	.1388	Sand	.....
Monroe Junction ..... Oct. 25 to	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Sand	Long Haul.
SHOVEL No. 2 (BUCYRUS S. S.)													
Farwell, 1st Cut ..... April 1 to May 14	5028	31786	6.32	38	132.31	836.47	259.83	19.35	122.33	3095 04	.0973	Sand	.....
Clare Clay Cut ..... May 15 to June 21	3112	16415	5.27	31	100.39	529.52	200.50	15.52	81.87	2297 78	.1765	Clay	Hard Pan.
Farwell, 2d Cut ..... June 22 to July 29	3176	29373	9.24	32	99.25	917.90	195.50	16.24	150.24	2869 55	.0908	Sand	.....
Clare Sand Cut ..... July 30 to Aug. 7	1359	8476	6.24	15	90.60	565.00	85.50	15.89	99.13	827 59	.0978	Sand	.....
Lake George ..... Aug. 7 to Sept. 18	4518	39724	8.79	66	68.45	601.88	323.50	13.96	122.79	4160 13	.1049	Sand and Clay	.....
Clutes ..... Sept. 19 to Sept. 29	1205	13260	11.00	19	63.42	697.90	71.66	16.81	185.04	1354 12	.1021	Sand	.....
Temple Clarence ..... Oct. 2 to Nov. 2	2209	17652	7.64	40	57.72	441.30	128.66	18.67	142.74	2815 33	.1595	Quicksand	.....
Temple, 2d Cut ..... Nov. 3 to Nov. 12	1124	9788	8.70	16	70.25	611.25	57.75	19.46	169.49	803 97	.0821	Sand	.....
Howell Gravel Pit ..... Nov. 14 to	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Gravel	.....
SHOVEL No. 3 (MARION S. S.)													
Samaria ..... April 8 to April 20	717	6114	8.53	12	59.75	509.50	57.00	12.58	107.27	651 17	.1065	Sand	.....
Howell Fair Grounds ..... April 22 to July 17	5570	36514	6.56	74	75.27	493.43	414.33	13.44	88.12	5117 89	.1401	Clay	.....
Howell Junction Gravel Pit ... July 18 to Aug. 2	2239	15905	7 10	33	67.85	481.97	115.50	19.37	137.70	2288 44	.1437	Gravel	.....
Pettysville ..... Aug. 2 to Aug. 27	1314	10233	7.78	21	62.60	487.30	114.25	11.50	89.56	1430 56	.1398	Quicksand	Very light face
Sexton's Cut ..... Aug. 28 to Sept. 23	1763	14175	8.04	34	51.85	416.91	128.33	13.95	112.20	2444 29	.1724	Sand	.....
Howell Junction Gravel Pit ... Sept. 24 to Oct. 1	627	.....	.....	14	44.78	.....	45.50	.....	.....	.....	.....	Gravel	.....
Chilson, at Station ..... Oct. 1 to Oct. 4	302	2231	7.38	7	43.14	318.71	26.67	11.32	83.65	386 12	.1731	Sand & Gravel	Very light face
Howell Junction, 1 mile south. Oct. 5 to	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Clay	.....
SHOVEL No. 4 (MARION S. S.)													
Samaria, South of ..... April 22 to April 28	325	3595	11.06	5	65.00	719 00	21.83	14.88	164.68	914 66	.2544	Sand	All work lowering by hand chgd. against this cut.
Temperance ..... April 27 to May 29	2874	23571	8.20	28	102.64	841.82	133.75	21.49	176.23	2546 62	.1080	Sand	
Pittsfield ..... May 30 to July 12	3058	24378	7.97	37	98.70	658.86	174.17	17 56	140.00	2339 98	.0960	Clay	
Churchill ..... July 15 to July 27	1184	7938	6.70	12	98.67	661.50	44.00	26.91	180.41	1074 20	.1353	Sand	
Bagnall ..... July 29 to Aug. 12	1788	16450	9.20	23	77.74	715.20	82.20	21.75	200.21	1066 63	.0648	Sand & Gravel	.....
Dairs Creek ..... Aug. 12 to Aug. 21	1026	8897	8 67	15	68.40	593.13	58.40	17.57	152.34	872 65	.0980	Sand	.....
Betsey River, north { Aug. 21 to Aug. 30	3152	32489	10.30	32	98.50	1015.28	156.58	20.13	207.49	2444 31	.0722	Sand	.....
" " { Oct. 21 to Nov. 5													
Crystal Lake Outlet ..... Aug. 31 to Sept. 21	2181	20244	9.28	37	58.95	547.13	130.66	16.69	154.93	2384 86	.1178	Clay	.....
" " ..... Sept. 23 to Sept. 30	834	16258	7.52	13	55.60	481.38	55.53	15.02	112.09	829 70	.1325	Sand	Light face.
" " ..... Oct. 1 to Oct. 12	1164	13066	11.22	19	61.26	687.68	73.17	15.90	178.57	1166 86	.0893	Gravel	.....
Betsey River, south ..... Oct. 13 to Oct. 20	835	8851	10.60	14	59.64	632.21	56.00	14.91	158.05	777 90	.0879	Sand	.....
Frankfort ..... Nov. 6 to Nov. 12	562	4999	8.90	10	56.20	499.90	27.50	20.44	181.77	578 19	.1156	Sand	.....
Homestead ..... Nov. 13 to Nov. 17	495	4814	9.72	9	55.00	534.89	22.91	21.60	210.12	412 99	.0858	Sand & Gravel	.....
" 2d Cut ..... Nov. 18 to Nov. 26	595	5070	8.46	14	42.78	362.14	35.56	16.84	142.55	748 58	.1269	Sand	.....
Temple ..... Nov. 27 to	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Quicksand	.....
SHOVEL No. 5 (MARION S. S.)													
Dickinsons ..... May 14 to June 20	1549	14830	9.44	19	81.53	770.00	.....	.....	.....	1747 65	.1194	Clay	.....
Park Lake ..... June 21 to Aug. 4	3901	36919	10.24	39	92.33	946.64	.....	.....	.....	3775 61	.1022	Sand & Gravel	.....
McBain ..... Aug. 5 to Aug. 9	506	4009	7.94	10	50.50	400.90	.....	.....	.....	410 04	.1022	Clay	.....
Cadillac ..... Aug. 10 to Sept. 1	2504	24152	9.64	31	80.77	779.10	.....	.....	.....	1981 00	.0820	Clay	.....
Lucas ..... Sept. 2 to Oct. 31	6665	66563	9.98	102	65.34	652.58	.....	.....	.....	7259 00	.1089	Sand	.....
SHOVEL No. 6 (BAY CITY IND.)													
Durand ..... July 22 to Sept. 21	4290	39999	9.32	54	79.44	740.72	.....	.....	.....	5044 88	.1482	Clay	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1079 95	.3078	Clay	.....

TOLEDO, ANN ARBOR & NORTH MICHIGAN RAILWAY.

W. R. BURT, RECEIVER.

Exhibit of Steam Shovel Work, Season of 1894.

LOCATION AND DATE.	TOTAL CAR LOADS.	TOTAL CUBIC YARDS.	Average yds. per Car.	Total Time W'k'd, Days	Average Car Loads per Day.	Average Cu. Yards per Day.	Net Time W'k'd, Days	Net Average Car Loads per Day.	Net Average Cu. Yards per Day.	TOTAL COST.	Av'ge Cost per yd., Cts.	REMARKS.
SHOVEL No. 1.												
Yuma.....April 12 to May 21	4200	34706	8.26	37	113.50	938.0	25.60	164.06	1355.0	$ 3655.16	$10\frac{53}{100}$	Sand; Short Haul.
Park Lake...May 21 to June 29	2759	23185	8.40	34	81.14	681.9	21.23	130.00	1092.0	2912.82	$12\frac{56}{100}$	Gravel.
Dickinson's..June 30 to Aug. 6	3559	20655	5.80	31	114.81	666.0	23.87	149.10	865.3	3280.22	$11\frac{04}{100}$	Clay. long haul.
Lake George.Aug. 7 to Oct. 3	4143	30428	7.34	48	86.31	633.9	28.66	144.56	1061.6	5118.78	$16\frac{82}{100}$	Sand. Clay, Quicksand,
Howell Gravel Pit...Oct. 9 to Nov. 23	2898	25731	8.88	44	65.87	585.0	23.87	121.40	1078.0	4403.71	$17\frac{11}{100}$	Long Haul.
	17559	134705								$19392.79		
SHOVEL No. 2.												
Oak Grove...April 2 to May 19	3911	26681	6.82	42	93.12	635.2	28.88	135.42	923.80	$ 3657.05	$13\frac{70}{100}$	Sand and Clay.
Pettysville ...May 20 to July 19	4512	31801	7.05	50	90.24	636.1	32.00	141.00	993.80	4782.32	$15\frac{03}{100}$	Cost Divides with
Howell Gravel Pit...July 20 to Aug. 8	1947	13527	6.95	17	114.53	795.7	11.55	168.57	1171.20	1508.32	$11\frac{14}{100}$	New Line, Chilson
Pittsfield.....Aug. 9 to Oct. 31	5935	33534	5.65	63	94.20	532.2	44.57	133.16	752.36	6359.48	$18\frac{56}{100}$	Clay.
Clare.....Nov. 14 to Nov. 30	1753	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....
	18058	.....								$16307.17		
SHOVEL No. 3.												
Byron..... May 2 to June 10	1609	6000	3.72	30	53.63	200.00	11.10	144.95	540.55	$ 2754.28	$45\frac{9}{10}$	Wet Clay in Ditch.
Vernon.....June 11 to Aug 4	3341	19811	5.92	45	74.24	440.20	19.60	170.45	1010.76	4439.89	$22\frac{4}{10}$	Hard Pan and Clay
Corunna.....Aug. 6 to Sept. 27	3787	25322	6.68	46	82.32	550.40	24.60	153.98	1029.34	5157.11	$20\frac{3}{10}$	" " " "
Monroe Junc..Oct. 1 to Oct. 16	407	4170	10.25	11	37.00	379.00	3.35	121.49	1244.75	654.08	$15\frac{6}{10}$	Sand.
Temperance .Oct. 15 to Nov. 12	1438	12984	9.02	26	55.30	499.38	9.10	158.02	1426.81	1859.66	$14\frac{3}{10}$	Sand.
	10582	68287								$14865.02		
SHOVEL No. 4.												
Elsie Gravel Pit....July .. to Nov. ..	7122	62480	8.77	98	72.67	637.55	53.42	133.32	1169.59	$13356.80	$21\frac{3}{10}$	Long Haul.

The President.—This paper of Mr. Rigg's is before you for discussion.

Q. How are these iron pipes constructed?

A. We use for culverts rejected water pipe.

Q. But for these used on the trestles?

A. The iron cylinders; they are largely cylinder pipes.

Q. Are they driven?

A. No. In the case at Dundee they are founded on solid rock. At Ann Arbor we drove piles and the cylinder was sunk into the gravel 2½ feet and filled inside with concrete. The piles are driven inside of the cylinder and allowed to project into the cylinder part of the way and the balance of the cylinder filled with concrete. We used at Ann Arbor and Dundee a cylinder resting on solid rock.

Mr. Sears.—Do you use wrought iron cylinders instead of cast iron or water pipes?

A. No sir. We never used the wrought iron, although we are considering it now.

Q. Do you take any means of protecting your pipe?

A. They were all covered with carbon paint.

Q. How did you protect the end?

A. For the most part they are unprotected as yet, but eventually we will build a wall.

Mr. Sears.—What is the average cost per yard for moving the material and the average load?

A. The average cost per yard for the entire time will be, I should think, about 14 cents. The figures show cost of labor and fuel and supplies of all sorts, but make no allowance for rental of plant.

Q. How about the hauling?

A. The average haul was 2½ to 3 miles. On one piece of work we hauled as high as 20 miles, and very little was hauled less than ½ mile. The average haul would be fully 3 miles.

The President.—Mr. Riggs, how much cheaper do you think the work could have been constructed per yard, had you had the advantage of a double track railroad, instead of working on a single track?

A. Well, I think that the cost would have been very much reduced. It is pretty hard to say what per cent., but the greater portion of our delays were caused by the interference of regular trains on the road. On the south end of the road, particularly south of Dundee, where we have the trains of our own road and those of the C. J. & M., we have had about 50 trains per day and the delay was considerable. We had one or two instances in this district where we did not avearge over 3½ hours work out of a 10 hour day.

Mr. Sears.—Will you be kind enough to describe the concrete work on the piers?

A. We put in piers at two points, using concrete composed of 3 parts of Milwaukee cement—composed of 2, 3 and 5, using broken stone that would pass through a 2 inch sieve. The body of the pier or abutment where the concrete was put into a mold, using on the outside the rich Portland cement concrete for facing, and using sandstone coping; we have used the Berea and also the Hocking Valley stone. The piers of both places were very low, being only a matter of 1 foot to 1½ feet from the natural surface of the ground to the bottom of the coping. They were small piers.

Mr. Sears.—What was the cost of that pier compared with first class masonry?

A. About one-half.

Q. What was that one-half?

A. The cost of the four abutments was in the neighborhood of $835.00.

Q. I mean per cubic yard.

A. That was about $5.50. There is no stone at all on the line of our road, and the authorities have been rather opposed to the introduction of the use of masonry, and concrete is an opening wedge to what I hope will be something better.

Q. I thought there was a quarry at a point near Dundee?

The President.—It is a very poor quality of limestone and would hardly be suitable for railroad work. We examined it and did not consider it suitable for first class work.

Mr. Granville.—I want to hear Mr. Riggs on that point, particularly the construction of the concrete in these abut-

ments, or the use, rather, of concrete on that particular kind of work. Now, I am something of an enthusiast in the use of concrete, and believe that concrete properly put in is as good as first-class masonry and will weather just as well, and I want to bring out some of these points. Now, Mr. Riggs, of course, has not had the experience with the particular work that was put in there—it has not been in there long enough for him to tell how long it will last. I have no doubt about that, however; the concrete is not a new article by any means, but it has not been justly appreciated by engineers. It is becoming better appreciated each year and is coming into more general use than ever before. I picked up some time last year an article written by the engineer, I think, of the Knoxville, Cumberland Gap & Louisville Railroad, describing the construction of a piece of concrete work at Lonesome Valley crossing, on their road. At that crossing, some 800 to 900 feet long and about 130 feet high, they had an old wooden structure that collapsed under a heavy freight train and necessitated abandoning that particular crossing. They made a temporary shift by running down on one side of the valley and coming up on the other, using that for a considerable length of time. They finally got ready to put in a permanent structure. It was found that there was no native stone within reasonable distance that could be used; they then concluded to use a concrete construction. The construction of the superstructure was girders on steel piers. These on heavy concrete pedestals and at each end to be a concrete abutment some 28 to 30 feet high, and upon these abutments was the bridge.

I think this article was written some 12 or 18 months after the work had been put in, so they had some experience as to its durability, but the most interesting part was the discussion brought out by the paper as to the use of concrete by them in different parts of the country and in different structures exposed to the air.

Mr. Riggs.—I will state that the use of concrete for foundations for railroad structures is by no means new. It has been used to a large extent by the engineers of the Northern Pacific and of the Great Northern. Mr. J. W. Hendrie, now

General Manager of the Northern Pacific, and Engineer of the Great Northern are cranks on the subject of the use of concrete. Mr. Hendrie has used it in arches, in piers and in abutments, and in fact in almost all classes of work where first-class masonry could be used, and he tells me, with good results.

Mr. Hendrie, in some correspondence which I had with him, about the time we built the Ann Arbor bridge, relative to the use of concrete in steel cylinder piers, recommended this class of construction very highly, but with the proviso which I think is proper, that unless the construction can be anchored in the solid rock, that piling must be used, or some other means, to prevent erosion. I believe that concrete is going to take a very large place in foundation construction, particularly in a country like some parts of Michigan where no stone that is at all suitable, is available.

Mr. Sears.—I should like to hear a word from Mr. Gates on this topic.

Mr. Gates.—With reference to economy, the question I would like to ask is, what kind of cement do you use for concrete,—whether you use natural American cements or Portland cement? I have been in the habit of using natural cement for concrete which is not subject to frosts. If the concrete is laid during frosty weather, where the concrete will freeze at night and thaw in the morning, the use of natural cements would, no doubt, be poor practice. It would be necessary to use Portland cement only. I have recently,—within a week or two,—had a little experience on a cylinder pier, in which the specification was to fill the cylinder pier with concrete that shall have piles driven into the cylinder. When this recent high water came on, we had a rise of 19 feet at one point and the cylinder pier was floating at the time it was to be concreted. We had to guy it up to the side of the concrete platform; however, as contractors, we had no control over the matter, for it had to be erected by a certain time, and the contract was let for the bridge so late in the season, that it was necessary to use all the time we had, and we worked, rain, shine or freeze, and in this particular cylinder pier the coping

stones are being set now, but I do not anticipate any very good results from it.

Mr. Riggs.—Don't you think that when that class of construction is founded on solid rock, that it makes a very good substitute for masonry?

A. If your rock surface is level, and if you get support below the surface, it would be all right. We excavated 9 feet from the surface of the ground to the level of the rock; leveled off the rock and used 1¼ inch anchor bolts, putting in three bolts to each cylinder, anchoring through the rock, so that our cylinders were there practically 9 feet below the surface and rested direct on the rock. The diameter of these cylinders was 8 feet, so that there is not much question as to their stability.

Mr. Granville.—I have known of these cylinders being founded on the rock where it is of uneven surface, and instead of smoothing off the surface to an area greater than that covered by the cylinder, the location of the cylinder was found and then a groove cut to take the cylinder plates; that groove was cut in as deep as necessary, so that when the cylinder was set in there it was leveled up. There is no chance for the cylinder, so far as I can see, to move on that rock except by means of a thrust sideways. If you get your cylinder in a pocket in the rock there is no great chance of the cylinder being moved.

Mr. Riggs.—These piers at Dundee will probably form a pretty good test of that class of construction. The stream has a great rise and fall. The high water mark at our bridge is 17 feet above the ordinary stage of water, and it is a stream that is subject to a number of ice jams. We have had five or six about one mile above our bridge, so the probability is that this class of construction will have a very thorough test there.

Mr. Granville.—Using concreted cylinders for piers is not a new construction. There seems to be a great deal of doubt in the minds of engineers as to the desirability of using that class of construction, however. I noticed, particularly, two bridges crossing the Mississippi at Clinton, Ia., two years ago. One is a highway and the other a railroad bridge crossing

close together; in fact, one crosses the other at the south approach to the river, or nearly so, and I think both of these approaches to the bridge from the river piers, are constructed of large steel cylinders carried down into the mud, I don't know to what depth, but there are piles driven inside and filled with concrete. Where there is danger from the floating ice or logs or other debris, bracing is used between to prevent anything of that nature getting in there and wrecking the cylinder, that is a solid web. Instead of using struts and diagonals, a solid web is used in between.

Mr. Gates.—The great difficulty, it seems to me, in cylinder piers, is to get the diameter of the cylinder pier large enough to have the proper bearing surface inside of it for the load of the bridge and the weight of the material inside of it upon the foundation below; whether this be piles or something else, or solid rock, it don't make any difference

Mr. Riggs.—Don't you think that the reduction of the diameter, which we used at Dundee on the plan which you submitted in your bid on that work,—don't you think that some scheme of that sort, where the larger diameter is at the bottom and reduces toward the top, would solve that?

Mr. Gates.—Yes, sir Of course you can hardly ever, in a clay bank, drive more than 6 or 7 piles inside of the cylinder pier, and those 5 or 6 piles will have to take all the weight.

Mr. Sears.—It seems to me that one of the principal objections is that you would want a retaining wall at the end of your bridge, and you could not get it. By the shore you want a retaining wall, and you could not make it with the cylinder.

Mr. Riggs.—At Dundee we have quite a long trestle on the north and a trestle bridge from the south. We have five to six hundred feet of trestle in addition to our span, and it would be impossible to shorten that.

Mr. Douglas.—How much cheaper are cylinder piers than solid masonry piers?

A. The piers at Dundee,—the entire work of building, —cost us about $2,450.00, while the estimated cost of masonry was $3,700.00.

Q. What would it have cost, Mr. Riggs, had these piers been put in with concrete with a heavy stone coping?

A. A very little more than the form of construction used.

Mr. Sears.—I haven't any doubt about the use of concrete for bridges. I would not hesitate to make a large culvert completely of it. I think, if properly proportioned, it would stand in this climate. There is no question at all but that it is cheaper than any stone you can use, and you can make large pieces cheaper than you can quarry it.

The President.—Are we through with the discussion of this paper?

Mr. Ames.—I was saying to Mr. Douglas that I built, a year ago last summer, some sidewalks of Louisville cement as an experiment, and about half of the blocks I made are in good condition to-day. The other half, the top is cracked and scaling off. The lower part seems to be in good condition.

Mr. Granville.—Right in the same line of experience, two years ago,—in 1894, rather,—I had a notice from the city authorities to renew my sidewalk, and I put in a concrete walk. At this time I was doing a little concrete work here in the city, putting in some curbing on one of our main streets, and I took the force that I had there, at the time when I was stopped from work, and went and put in this concrete sidewalk with the force. I experimented a little on it in this way.

The walks usually put down in this city are made entirely of Portland cement. The bottom of a poorer quality than the top dressing. I got some Milwaukee cement, which cost me 75 cents per barrel, and put the bottom 5 inches, and on that another made in proportion of about 1, 2 and 5; 2 of sand and 5 of gravel. The top inch was put in of Portland cement, made in proportion of 1 to 1, and the sidewalk is in very good condition to-day. It has not shown a crack and has given perfect satisfaction, except in the case of one or two blocks, and my opinion is that the work at that point was not properly done. The surface is all right. It is not cracked, nor does it show any signs of giving out, and this is its second winter, but in walking over it, it gives forth a hollow sound. There are perhaps 5 or 6, or perhaps more, blocks in the whole length of

that sidewalk, 100 feet in length, that shows a hollowness. The reason for that is this: The foreman who had charge of the work got in too much of that bottom, and allowed it to become dry, or nearly so, before putting the top coating on, and consequently there was not a proper adhesion between the upper and lower coats. The cost of that to me, (and my labor was more expensive than it ought to have been), the whole thing cost me about 8 cents a square foot, and you can not get a very good job done, using Portland cement, for less than 12 to 14 cents. You can let a contract at 12 to 14 cents for Portland cement walk, 5 inches thick, but I defy you to get a piece of work done that will give good results at that price. I used Milwaukee cement to see how cheap it could be done with good results.

THE MECHANICS OF A CREAM SEPARATOR.

H. K. VEDDER.

The problem here presented may be considered one in agricultural engineering. It is well known that the modern method of cream separation in butter-making requires that the cream be taken from the milk immediately after milking. This is accomplished by some application of the so-called "centrifugal" action, a purely mechanical process; and machines for the purpose are called cream separators.

Such a machine consists essentially of some form of vessel or bowl, capable of rotation at high speed about an axis, with suitable devices for receiving milk into the bowl and for conducting from the bowl streams of the separated cream and the "skim-milk." To permit the high speed of rotation that seems to be necessary, not only must the construction of all parts be very perfect and their adjustment delicate, but the rotating parts must be carefully designed to avoid rupture while in motion.

Separators of many forms are used in the dairy department of the Michigan Agricultural College. Among those in operation there during the year of 1894 was one for which was claimed, by its manufacturers, marked superiority over others, in the matters of cheapness, lightness, ease of running, etc.; much of the claim being based on the fact that the metal used in the construction of the machine was very light, being very nearly pure aluminum. The actual composition of the metal was said to be 95 per cent. aluminum with 5 per cent. of iron. While the machine was under trial at the college, a report came that one of the same kind had burst while being operated for exhibition purposes at a county fair. The college dairy experimenters conceived a distrust of the separator, which led to the analysis and tests recorded below.

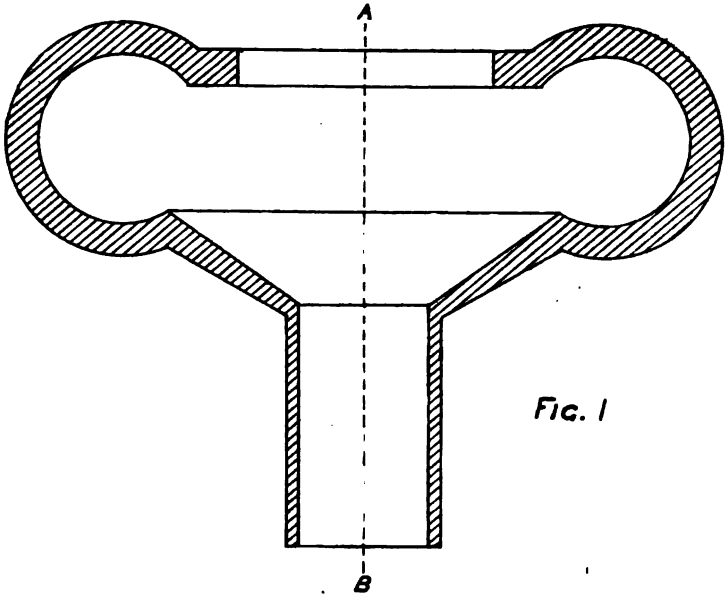


FIG. 1

The form of bowl used in the separator is shown to scale in Fig. 1, which represents a vertical section of it, except that in the casting the sharp edges are rounded off. It is symmetrical with respect to a vertical axis AB, about which rotation occurs. This bowl was designed to attain and maintain a speed of from 6,000 to 8,000 revolutions per minute, in practical operation. The higher number will be used in the analysis.

We shall first attempt to determine the stress on the metal of the bowl, induced by the given speed of rotation. The problem is very similar to that of determining the stress in a revolving flywheel rim or a grindstone. From mechanics we know that if a body rotates with a uniform velocity about an axis, lying in a plane of symmetry, there is induced a force away from the axis$=w^2Mp$, in which w=the constant angular velocity of rotation, M=the mass of the body and p= the distance of the center of gravity of the body from the axis. If we were to take as the body under consideration the half of the separator bowl which lies on one side of a vertical plane

through the axis, this formula would give us the total force exerted on or by the other half, i. e., the stress in the vertical section. But the stress in such a section is not uniform over the whole section, being evidently greatest at those points of the section farthest from the axis. So it would seem that we would arrive at more satisfactory results if we would deal only with that portion of the bowl which may be conceived as generated by a portion of a circular ring, shown in Fig. 2. Over any vertical section of this portion of the bowl we may, without great error, consider the stress to be uniformly distributed.

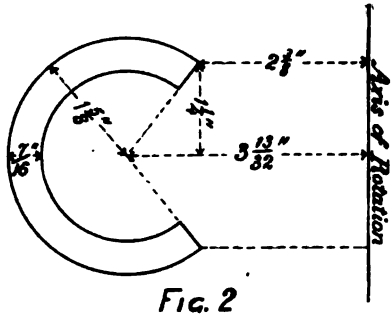


Fig. 2

The dimensions given in Fig. 2 are from actual measurements. Combining these dimensions in obvious ways, we find the volume of metal in the portion of bowl generated by the ring to be 70.4 cubic inches; whence, is obtained the weight=7.27 lbs., and the weight of the half bowl=3.64 lbs., the weight of the metal being 178.4 lbs. per cubic foot. Then for substitution in the formula given above, using the foot, pound and second as units,

$$M=\frac{\text{wt. of half bowl}}{\text{acceleration of gravity}}=\frac{3.64}{32.3} \text{ mass units.}$$

$$w=\left(\frac{8000}{60}\times 2\times\frac{22}{7}\right) \text{ radians per second.}$$

$$p=(\text{something between 2.17 in. and 3.2 in., say 2.5 in.})=\frac{2.5}{12}\text{ ft.}$$

(The determimation of the limits between which p lies, consists in considering all the metal of the half bowl to be (a) concentrated in a semi-circular wire of radius$=3\frac{26}{64}$ in. and (b) in one of radius=5 in.; and thence deriving the limits as given above.)

Therefore, the tension to be resisted being denoted by T,

$$T=w^2Mp=\left(\frac{8000}{60}\times 2\times\frac{22}{7}\right)^2\times\frac{3.64}{32.2}\times\frac{2.5}{12}=16503 \text{ lbs.}$$

But this is due to the revolution of the empty bowl. An additional stress will be induced by the revolution of the contained milk. When the separator is filled with milk, a volume of the liquid weighing 4 pounds may be considered as affecting the required tension, and a computation similar to that above places the amount to be added at 5,252 pounds. Hence, the total tension under working conditions is 16503+ 5252=21755 lbs. to be borne by 5.6 square inches of section. This gives a stress of about 3,900 pounds per square inch.

This stress would not seem to be excessive, to one who has become filled with popular notions as to the strength and utility of the metal aluminum, and it must be confessed that at the time of making the analysis the writer felt that the stress found was within safe limits. But, to complete the examination, standard test pieces of the metal used were obtained through the kindness of the manufacturer, and these were broken by tension in a Riehle testing machine at the college. The results were rather surprising. Sixteen pieces were broken, showing a variation in ultimate tensile resistance from 9,814 lbs. per square inch to 14,864 lbs. per square inch; and giving a mean value of 12,867 lbs. per square inch.

Comparing this ultimate resistance with the stress induced by ordinary working requirements of the separator, it is seen that there obtains a factor of safety of about 3, which would seem to be much too small for machinery of the kind in question.

It may be added, in conclusion, that since this paper was written, I have been informed that the manufacture of the separator with this particular form of bowl has been discontinued.

Prof. Vedder.—I have brought along several of the broken pieces, and anyone who is at all interested in the metal aluminum, can find them on the table over here, with a card attached, giving the peculiar behavior of the specimen under stress. I wish here to speak my thanks to Prof. Pashby, of the Agricultural College, who made the tests for me.

The President.—This paper is before you for discussion, gentlemen.

Mr. Sears.—I did not understand where that failed; that machine.

Prof. Vedder.—On just such a section, a diameter section. The one that burst went through the roof at Hornellsville, at a county fair.

Mr. Hubbell.—Had the machine been built of steel, with the well known strength of steel, as against the lightness of this aluminum,—would the lightness have the advantage?

Prof. Vedder.—I have not gone through the computation. I imagine the aluminum must have the advantage over the steel. I think the increased weight of the steel will more than overcome the advantage resulting from its strength. I think the manufacturer of this bowl has moved to Lansing within the last few days, and intends to make another form of bowl there. I think he is going to use the same material with a much smaller bowl.

Mr. Sears.—It is a good plan to leave the farm house where he goes to work.

Prof. Vedder.—The one at the College got refractory and nearly killed the head of the Agricultural Department. One of the bearings became over heated. It was not evenly placed. With a machine able to rotate at such a high speed, a little lack of centering means a strain on the bearings.

The President.—The subject of aluminum is brand new to me. I have known of its existence, but I have not investigated the subject, and I would like to know if anyone does know to what extent aluminum is being employed in machinery. So far as my observation goes, aluminum, so far, has been most largely used in making household utensils and ornaments.

Mr. Hodgman.—Isn't it principally used now as an alloy for other metals?

Mr. Wells.—I couldn't say. I took considerable interest in examining the exhibit of Gurley Bros. at the fair, and I visited their works at Troy this last year, and they told me that in the manufacture of levels and transits, they have found that the metal is deficient for bearing surfaces. They have made some levels, which they say have met with a good deal of suc-

cess, but in all the bearings they have introduced brass or bell metal.

Prof. Vedder.—Anyone who cares to go into the use of aluminum will find it treated in Mr. Kent's Mechanical Engineers' Pocketbook. I find there that the stress per square inch, as ascertained from a large number of tests, is put down at 15,000 pounds per square inch for castings. Before reading that, I had supposed that the ultimate resistance was considerably higher. Rogers, in his book on aluminum, says that it has an ultimate strength of 26,800 pounds.

Mr. Wells.—When the prices of aluminum were cheapened,—about the time aluminum was worth $1.50 a pound,—a statement was made somewhere that aluminum possessed about the same tensile strength as steel, but everything I have seen since then, has tended to lower that estimate.

Prof. Vedder.—I don't mean to say that I have been laboring under that delusion for some time past.

Mr. Wells.—I have been distrusting that statement, which I heard some years ago, and I was entirely at sea as to what was a safe tensile strength of aluminum; 26,800 pounds, you say, on one authority?

Prof. Vedder.—Yes,—that is, of course, a later work. 12,876 is another estimate.

Mr. Pashby.—Taking equal weights, I think aluminum would have about the same tensile strength as boiler steel.

Mr. Wells.—I have heard that by using a small quantity of aluminum with steel, the tensile strength of the steel was increased.

Mr. Hodgman.—I think I read in the Engineering News, some time since, that it can be employed up to about 5 per cent. to advantage, but I have not pursued the subject. Can anyone help us out on that point?

Prof. Vedder.—I am not sure, but I think that a small quantity is used sometimes for the purpose of making pig nuggets. It seems to drive out the impurities, air, etc.

Mr. Hodgman.—I have read statements within the past year or two, to the effect that aluminum is now principally used for an alloy with other metals, but in small quantities, to

improve their casting qualities and strength. On the other hand, aluminum alloyed with some other metals seems to possess high tensile strength and other requirements for mechanical purposes.

Mr. Pashby.—The limits are between 2 and 15 per cent. Never less than 2 or more than 15 per cent.

Remark. Aluminum is being introduced in the manufacture of bicycles to lighten up some parts, though I do not know with how great success. I know that one bicycle firm has recently purchased a considerable amount of aluminum for parts where strength is not particularly the point desired, and at the same time it tends to lighten the machine.

The Pittsburg Reduction Company has recently located its plant at Niagara Falls, to take advantage of cheap electricity in the manufacture of the metal.

Q. Do we understand from this paper, that all these separators are dangerous? Have there not been a great many throughout the country, which have been running successfully for years?

Prof. Vedder.—There is no question about it.

I had in mind bringing up a discussion on aluminum from another point of view. What should be the factor of safety, for machines to be operated at such a high rate of speed?

The President.—Can't Prof. Vedder tell us?

Prof. Vedder.—I have an opinion. I think we ought to have factors of about eight.

Mr. Sears.—I would make it ten, and then get out of the way.

Mr. June.—What was the power employed?

Prof. Vedder.—An electric motor.

Mr. June.—Was any test made with hand power?

Prof. Vedder.—I am not sure. I answered your question in that way because all the separators are run by electric power at the College. At times, for real practical purposes, they do operate them by hand. I don't know whether they can get up to that speed of rotation in that way. I believe they must attain the minimum,—something like 6,000 revolutions,—

in this particular machine in order to get a clean separation of the cream from the milk.

Mr. June.—I know they are making hand machines, and in many cases, of course, they must be used in order to meet the practical needs of the creamery methods.

Prof. Vedder.—I think that makes no difference in the required speed of rotation. The machines must be so constructed as to bring up the speed of the bowl to the same point.

Mr. June.—But that is not the question. The idea is whether they don't do it by hand?

Prof. Vedder.—I fear they go beyond it by electric power, and that is one reason why our factor of safety should be so high. It is next to impossible to count the revolutions of a machine rotating at so high a speed.

Mr. Scars.—There seems to be no uniformity in the strength of this metal.

Prof. Vedder.—It is very erratic. We have there, one specimen broken in two places—the first fracture covering a larger area than the second—the tensile strength derived from the first smaller than from the second.

Q. What is the lowest?

A. I gave the minimum of 9,114 pounds per square inch.

Mr. Rogers.—Are other makes of machines in the habit of upheaving like this one? There are, I suppose, a number in use?

Prof. Vedder.—I suppose it is a pretty small percentage of the whole number that has ever blown up.

Mr. Hodgman.—We have two of those separators near where I live, but they are both run by hand.

Mr. Sears.—You better move.

Mr. Skeels.—He wants to build a storage reservoir.

Mr. Pashby.—As to the question of running these by hand. That is done at the present time in the dairy department. The power required is only a small fraction of a horse power, and a man can turn a crank quite handily for an hour, the time required for separating about 200 pounds of milk. That is with a comfortably, easily running motion.

Mr. Hodgman.—A friend of mine, Mr. Brown, editor of the Michigan Farmer, runs a separator at his house, near where I live, and he says it is no harder to run than a fanning mill.

Mr. Pashby—A point that has not been brought out in this, is the extension that the metal underwent during the test. I didn't have any extension meter to put on, and I can only give a rough approximation, but in scaling the piece, I find an extension of about 1 7-10 per cent. in seven inches, and also a reduction of about 8 per cent. in the area of the cross section, at the point of fracture.

Q. Mr. Pashby, you conducted those tests with these pieces that are here; could you favor us with a little lecture on your experience in making these experiments?

Mr. Pashby.—I don't know that I could say anything that has not already been brought out.

The form of test pieces that I designed for this work is as represented here (indicating). Then, as a variation, I had the outside skin taken off from two or three specimens, and I can say that the metal is very difficult to work in the lathe. It is very much like rubber; it is very hard to turn and frills up in an unsatisfactory manner.

The testing machine is one that is worked by hand power. I suppose the results are not quite so accurate as might be obtained by the use of machinery—that is a power machine.

I would say that this extension was measured by taking dividers and spacing them about seven inches here, and that I had to put on a weight of about 3,000 pounds on this piece and there was an extension of about 12-100 of an inch, amounting to 1.7 per cent. in that length of seven inches.

The President.—Did it regain its original position after releasing that power?

A. Yes, I removed the load at 2,000 pounds and it went back very nearly to its original length. I could not be exact about that.

The breaking load on this piece was 3,850. It was on that section, and that amounted to 14,092 pounds per square inch.

Q. Did you establish the elastic limit in this test?

A. No, I did not. This piece that broke here in six places I should attribute to its being put into the jaws of the testing machine improperly. There must have been a twist on it, so that it tore, like a piece of paper.

Q. I should not think you could take the results then, if you did not get it into the machine well?

A. I computed this separately from the others. This section here (indicating) is the one that gave me 9,814 pounds to the square inch. That section broke at 8,000 pounds, and this at 8,405 pounds.

Mr. June.—These pieces are castings?

A. Yes.

Q. Are they capable of annealing?

A. I think not.

The President.—Mr. Sears asks the question as to how this behaves under compression?

A. I don't know. I should think, though, that it would not compress very well, because it bends easily.

Mr. June.—What results are obtained by working this, and do the same conditions exist between cast and wrought aluminum, as between cast and wrought iron?

A. I could not say.

The President.—I think that would be a first rate paper for some one to give us next year. We seem to have more questions than knowledge on this subject.

A BASKET OF CHIPS.

MR. SKEELS.

One industry of the engineer and surveyor is platting additions to cities and villages, and making a map thereof. We are compelled by law to submit said map to the auditor-general of this state for his approval. This is humiliating. While honesty and integrity stimulate him in the discharge of all official duties, his lack of proper knowledge disqualifies him to pass judgment. Justly, we should not censure him; this duty has been attached to his office, unaccompanied with the qualification necessary for the proper discharge of such duty. Any effort that would result in amending this act, would be a move in the interest of right and justice. A commission of members of this association can formulate a plan—make specifications— that would rid us of this humbug.

At the annual meeting of your board of directors, the question of advancing members of this, our, association to the exalted position of honorary members, was informally in discussion. Is not constant, earnest work for the advancement of the best interests of this association, regardless of age or infirmities, the best record for such advancement?

In January, 1899, occurs the twentieth anniversary of the organization of this society. It seems to me this would be a most fitting time for a royal banquet, commencing now with small contributions to a sinking fund from each member, to be kept up annually, thereby securing a sufficient fund for the committee to prepare a feast that would tickle alike both palate and intellect.

Do the members fully appreciate the genuine worth, the intrinsic value of "The Michigan Engineers' Annual?" Do they know that some of the papers read at these meetings and published in its annual are the best, are authority on the subject which they have under discussion? The authors are

practical men. Each one's paper is a digest of that matter up to date. Already progressive societies are asking for the annual to place on their tables. Our best attorneys read it, and ask the engineer on the witness stand, "Are you a member of the Michigan Engineering Society?" I fear that many of us do not realize that it is a hand to hand conflict with the secretary to get the annual out on time. If each one would assist this worthy officer in this by getting an advertisement from somone in his locality, and each member would insert his card, a nice sum would be the result.

Do we realize the usefulness, the far-reaching influence and practical worth of the Michigan Engineering Society? What it has actually done for the public good should be not the measure but the foundation of its coming service. And do these young men, enrolled among its most worthy members, fully realize that soon they must take the helm and guide this ever-growing organization on to more beneficial, more practical usefulness? The ones that have brought it to its present standing must pass on. Time will come when, though every joint and bearing of the machine be cleaned and oiled, it will not keep in proper adjustment—will cease to work. Some of us older ones have done much land surveying—even before that county surveyor had adjusted the work of the government surveyor—and often in projecting a line we came to a seemingly impassable swamp, the accumulation of ages. We pass on into it, setting stakes or pickets at intervals in line. Each time we move our instrument we look for some way to go around and shun the rough looking path; but when we got through a feeling of satisfaction would come to us as we looked back over the work and saw our pickets standing in regular alignment. So, my friends, at the final passing, may we look back on a life with pleasure, and the same satisfaction, and see some monuments standing in perfect alignment.

The President.—Kate Field says, "You want to reiterate reiteration," and I was glad to have Mr. Skeels bring out that point of assisting the secretary in obtaining this advertising.

Mr. Granville.—One point mentioned in Mr. Skeels' basket I thought was a good suggestion, and I hope means

will be taken by which it can be followed out, that is a banquet three years hence. I think it would be a very good plan to start and create a "sinking" fund, and a little applied during each of the coming three years, would not be missed and, in the aggregate, would amount to considerable and enable us to do the thing up in good shape. I think that suggestion ought to be carried out.

Mr. Walker.—That banquet is two or three years off. It don't seem to me that it is necessary to worry about that. It seems to me it is only necessary to appoint a meeting at Saginaw.

Mr. Skeels.—My idea of that, was to begin now and to have small sums contributed, for instance, if each member feels so disposed, say 25 cents a year, and by that time, 1899, we would have sufficient. My idea of a banquet was not a spree or a hurrah, but to get some of the best talent we can, and have them advised of it long enough before so they can prepare themselves properly, and have a good, substantial meal at the proper time, and have the evening spent in what might be called an intellectual feast,—perhaps interspersed with something lighter; that was the object I had in view in writing that. By commencing now, we can get ourselves thoroughly prepared. It is not necessary that each member shall contribute, but if it is agreeable to all to do so, I think we can have a meeting that would be very beneficial.

Mr. Hodgman.—I believe very much as our friend, Mr. Skeels, does in regard to celebrating our twentieth anniversary. I think it is a good time and I feel as he does as to the matter of holding the banquet. That would be an incidental affair. I am a great believer in mixing up with our annual meetings a little matter of lighter vein. I think it comes in as the dessert does with our regular meals.

I have felt that perhaps in the attempt we have made twice, to have these social meetings, perhaps the members had an idea it was meant solely to be funny. Now, it strikes me that the best part of the fun is if you don't have too much of it. You must have it mingled with something of a different

character. If you want to have the best effect of a real funny story, it must come in contrast with something that is not so funny.

If we could have a regular prepared program with someone for a toastmaster who had the right faculty for bringing out the members, and have a program of addresses, some light and gay and funny, and others that are not funny, I hope we can have it.

The President.—Mr. Appleton, let us hear from you on this.

Mr. Appleton.—Well, I have been cogitating. Pretty big word for me. I have been thinking, Mr. Chairman, that that was not a very big basket, but Skeels used to be a good chopper and he hasn't forgotten how. They say a good chopper cuts big chips, and three or four of those chips fill that little basket.

All of these suggestions seem to be all right. This is the seventeenth anniversary of the society; there are three years before the twentieth. I do not know but our friend, President Lincoln's, idea was a good one, "to get to the river before you cross it." We have nearly one-seventh of the time to cross over before we get to the twentieth. May we all pass over and reach it. Now, I think it would be an excellent plan, while it is perhaps a little bit too early, to start in with this thing.

Mr. Hodgman.—It strikes me that the proposition is not to go at it and to get up an entertainment now, and arrange all the details, but to consider the propriety as to whether we shall do something of that kind at that time. If we know we have a river to cross, we will be ready to cross it when we get there.

Mr. Appleton.—The object is to build a bridge and have it ready when we get there. This chip on that subject, I understand, is to erect a bridge so that we can march across *veni, vidi, vici*, in fact as Julius Cæsar did.

Mr. Granville.—Then I will put it in that shape, although I thought it would come better from Mr. Skeels; but I will make a motion that the secretary be requested to let the members of the association know that this has been contemplated, and stating that any donations offered would be received and applied to that purpose.

Motion supported and carried.

HISTORICAL NOTES.

L. G. STUART.

If any other person than Mr. Dorr Skeels had asked me to write a paper for the Michigan Engineers' Association I would have declined with thanks. But Mr. Skeels is a friend of mine,—at least I always considered him such,—and in deference to his wishes I have consented to prepare something for your learned society. My paper, let me be understood at the very beginning, is not for your instruction, for what I do not know about surveying would make a fair sized library. When it is said that a politician has gone off on a tangent, I know what is meant, but when a surveyor talks of tangents I confess myself up a stump, and the plumb always suggests to me something that grows on trees. I will not endeavor to instruct this learned body, for by so doing I would make myself ridiculous and cover my friend, Mr. Skeels, with confusion, but it is possible I may entertain you for a few minutes and it is with that purpose in view that I write this paper.

I have in my possession an old document, printed in Washington, to accompany a bill in the House of Representatives. It is dated March 6, 1838, and will doubtless be found in the house documents of that year. But as all of you do not possess the annals of Congress and do not read them if you do have them, at least I do not the few that I have, I will take it for granted that some of you, at least, have never seen the document I refer to.

The bill which this particular document accompanied was one to increase the compensation of the assistant surveyors in Michigan. They had been receiving $3.00 a mile as the maximum and wanted $4.00. The increase was strongly recommended by Robert T. Lytle, then surveyor general, with headquarters in Cincinnati, and in urging the matter, among other things, he wrote:

"The tract of country now in progress of survey in Michigan (he means northern Michigan) presents greater obstacles to the surveyor than any portion of this surveying district. It is almost a trackless and interminable wilderness, covered with an unbroken forest, a large portion of which is tamarack, hemlock, pine, cedar, maple, etc., and abounding with burnt and fallen timber, thickets, swamps, marshes and ponds; all of which render the progress of the surveyor exceedingly difficult, laborious and tedious, and the conveyance of provisions by wagon or any other wheeled carriage impracticable. And the surveyors have frequently been obliged to leave their pack horses behind, and for several days in succession pack their provisions on their backs. To this may be added the high price of provisions at the frontier settlements, and the great difficulty of procuring their chainmen and other hands, and the high wages paid to them, together with the increased exposure of their health and lives in the most inclement season of the year."

He further says that it is difficult to engage experienced and skillful surveyors, and eloquently urges that the rates of compensation may be increased to a proper figure. He appends to his recommendations a few letters from the assistant surveyors, in which they describe the difficulties of their work. As this meeting is being held in Saginaw, as charming a city as will be found in all Michigan to-day, I will quote extracts from a couple of these letters written from this quarter. The first that I shall give you is from Lewis Clason, written from Mosquito Headquarters, August 13, 1837. He left Cincinnati on July 11, reached Detroit on the 25th and then, after an eight day voyage in a "little seven by nine sailboat," reached the mouth of Pine River, on Saginaw Bay, from which point he wrote. He vividly describes the difficulties he has encountered and overcome, or tried to overcome, of the depth of the water in the swamps and the scarcity of provisions, and then he continues:

"In addition to the swamps there is another annoyance, for the present, even less tolerable. I allude to the mosquitoes and gnats. They are more numerous and voracious than

I have ever met with elsewhere. I do not doubt but that their number is sufficient upon every quarter acre to consume the last drop of blood in my entire company. They swarm about us in a cloud, not to guide us through the wilderness, but to devour. But thanks to the season's changes, a few weeks at most and the early frosts of this latitude will give them their quietus."

But it is left to J. A. Rousseau to vividly describe the mosquito, and he does it under date of September 1, 1837, from the Saginaw Bay. He had been having a hard time of it finding his lines and following them, and not the least of his troubles was the fact that "the circumambient atmosphere was groaning under the burdensome load of countless millions of myriads of mosquitoes, whose bite was like the sting of so many bees. You can have no idea," he writes, "how troublesome the little, slender, soft-billed, weak-looking, long-legged gentry are; but when I tell you that they bite a man through his clothes in a thousand places at a time, and through a thick pair of leather gloves, you will, like me, think they are not so contemptible as you at first imagined."

With the possibility of making you weary, I will quote no more from the ancient document, but will refer to an early Michigan surveyor whose name stands high in the annals of his state. I refer to Lucius Lyon. He came to Michigan territory about 1821 from Vermont, and for many years worked as a surveyor. In 1833, when off in the woods, he was nominated as a delegate in congress from the territory. With little, if any, campaigning on his part, he was elected and served the term of two years. Michigan applied for admission to the union and in the constitutional convention of 1835 he was a delegate. The first legislature elected him, by a unanimous vote of both houses, as one of the first two senators from Michigan, and in drawing cuts to see whether he should hold the long or the short term he drew the short. The admission of the state entailed a long and weary contest which doubtless most of you are familiar with. Ohio wanted the Toledo strip of territory and got it, and in exchange for it, through Mr. Lyon's efforts, Michigan secured what is now our

upper peninsula. Mr. Lyon served four years in the senate and subsequently a term in congress from the western district, then the second district, of Michigan. At the close of his congressional term he was appointed surveyor general with headquarters in Detroit, and died in 1852. This, briefly sketched, is the career of one of Michigan's ablest men of the early period, and now I will give you a couple of extracts from letters written by him, found in the letter press books which he preserved and which still exist. One was written April 12, 1838, and relates to surveying, giving advice to a young friend who has just secured a contract:

"You want patience, industry and perseverance to go through with your contract," he writes. "You must consider that you will not be able to make any money of consequence unless you push ahead as fast as possible. You must be out as soon as you can see daylight in the morning and go as long as you can see daylight at night. There is nothing like energy and industry to help along in such business. The most rapid progress I ever made in surveying was in the winter, west and northwest of Fort Gratiot, in one of the worst timbered, swampy countries I ever saw. I subdivided those ten townships in twelve weeks, including the time spent in going out and returning to Detroit, averaging for the whole time a fraction over eight miles a day, including Sundays, which we did not stop to keep. But I never worked so hard in my life and believe I never shall again."

In June, 1843, writing to a personal friend, Mr. Lyon told of some of the public work he had done, and this letter, or a portion of it, may be of interest historically. "I spent ten years of my life in surveying public lands, Indian boundaries and state boundaries in Michigan and Wisconsin, and no surveys have ever been more faithfully or accurately made than those of mine," he wrote. "Every line was run by myself personally, and in running them I have walked in the woods more than 50,000 miles. The boundary between Illinois and Wisconsin is one of these lines and was established by me as commissioner on the part of the United States. The meridian running north from the surveys in Illinois and crossing the

Mississippi at Rock River Rapids, and re-crossing it again near the mouth of Fever River, and passing near the town of Galena and thence on to the Wisconsin River is another. Most of the mining country in Wisconsin was surveyed by me, as well as a large portion of the State of Michigan on the eastern side of the Lake."

Trusting that the meeting of the association may be pleasant and profitable and that Grand Rapids may have the pleasure of entertaining you next time, I am,

Very respectfully,

L. G. STUART.

QUESTIONS FOR THE MICHIGAN ENGINEERING SOCIETY.

Question proposed by Mr. Hubbell:

"How can the wood platform on top of piles, which constitute the foundation of a stone pier of a bridge be preserved? In the original construction, this wood work was under water, but now it is exposed to the atmosphere by reason of the water receding."

Mr. Sears.—Build a dam below and raise the water.

Mr. Skeels.—Saw it off, under the water, and let it down.

Mr. Hubbell.—I would like to ask without joking, if there is any way of covering that, that will protect it?

A. The best thing I know is wood ashes.

Mr. Holmes.—I would suggest treating it with a solution of silicate.

The President.—In the paper I am down for, I have some points upon that subject—I won't take up your time now.

Mr. Sears.—In 1867 I placed 68 piles under a draw span, —oak piles. They were cut in the winter and seasoned in the water, you might say. Driven and left about 3½ feet above the average low water.

I bored in each of them, and plugged them with salt, and they were covered with a platform of good timber. We cut them off two years ago and they were in pretty good shape, after 29 years.

Q. You bored and plugged them with salt?

A. Yes, sir. I don't know how much good the salt did, but they were in pretty good condition.

The President.—Salt is a good antiseptic. The decay in wood is caused by the fermentation in the sap; fermentation promotes the growth of germs, and if you introduce some antiseptic, these germs are killed and the wood consequently preserved. The only objection is that salt is so soluble that

upon exposure it washes out; that, also, is the objection to the other systems of preserving timber, which use soluble salts.

Mr. Leavenworth.—A man on the west side made the statement to me that he built a sidewalk some years ago, and at the same time his neighbor, whose property adjoined his, built one; he says that he filled his, after excavating between the stringers, with refuse salt from the salt works, and that that part which had the salt rotted out more quickly than his neighbor's, which did not have it.

Mr. Sears.—It wasn't good salt.

The President.—It would be a question of getting the salt into the timber, and unless you have a well seasoned timber, it cannot be done very well. If that timber was put in green, with the sap in, it is a question whether it would do any good. It might protect the outside and induce dry rot at the heart. If the timber is well seasoned, I should think that the docks mentioned, if a little head of water were kept on them for a time, it would force it down, but I can see that you have a very unfortunate condition of affairs.

Q. I would like to ask Mr. Hubbell if that is decayed now?

A. I have not examined it closely,—the extent of the evil only revealed itself to me recently, and I am studying it closely.

Q. Can't you put a casing around it and fill it with concrete?

A. There is fourteen feet of water at this point. The water in the river was sixteen feet deep at the time we built the bridge, and we sawed the piles off thirty inches below the surface of the water and put a platform on, like this table. It is 26 feet square and there are 100 piles. After driving the piles, I put in all the sand I could drop in among them. The stone pier, which was 22 feet in diameter, is put on top of this platform, which is a foot thick. Of course the river has been dredged, which partially accounts for the lowering of the water, and the whole water of the lake has lowered somewhat, so that the water has receded three feet.

The difficulty is to get this dry or else to keep it wet; the boats passing back and forth wash the water up, even to the

top of the platform frequently, and there is a difference in the rise and fall of the water.

I had thought of the salt remedy and I had thought of taking something of the nature of matched flooring and letting it extend down two or three feet in the water, and one or two feet above the platform, thus forming a rim around the platform. The siding would have a tendency to keep a free circulation of air, and then putting twenty or thirty barrels of salt around. I would willingly use up fifty barrels a year, if it would do any good, but I am not sure about that salt penetrating and reaching the foot of the piles. It is eleven feet to the central portion of this.

Mr. Wells.—I have serious doubts of its getting in there if the timber was not seasoned.

A. No, it was green timber.

Q. How about the practicability of filling in there with cement?

Mr. Hubbell.—I had thought of an iron or wood casing, but it would be quite expensive.

Q. Couldn't you cut them off?

Mr. Hubbell.—How would you get in there, twelve feet? It is on Manistee River, a swing bridge.

Q. And in the receding of the waters, you have been left high and dry. I should think the idea which has been suggested of putting in some form there, so you could build your concrete over that, would be about the only way in which you could have any great success.

Mr. Sears.—Did you put a curb around to hold the stones?

Mr. Hubbell.—Why, I put in what stones I could, filling them clear to the top in the sand, but there are few stones on the outer edge.

Mr. Rogers.—We have a similar condition on two of our City bridges and I thought seriously last spring of putting boxing around these and putting concrete over the grillage and giving it sufficient slope so that the water would run off, and I was afraid rot might set in, under the concrete.

Mr. Wells.—If you excluded it thoroughly from the air, you wouldn't have any rot, in my judgment.

Mr. Hodgman.—There is a gentleman present who has had some experience in this line, Mr. Hunt.

Mr. Hunt.—My experience would not do any good in that case. I think after they were well cemented in, the piles would be all right. If I had that bridge to contend with, I think I should put the cement in, from the bottom up.

Mr. Rogers.—We have underneath this grillage, a rip rap, and the piles are not exposed. It is simply a part of the grillage. Most of the time it is above water.

Q. Are those oak piles?

A. Yes, sir. It is not the piles we are thinking about, as much as the timber on top of the piles. I was not worrying about the piles, because they are still wet.

Remark. I have two feet of space that I have sheet piled.

Mr. Wells.—I should think that you would sheet pile that. You have a lot of stone in the bottom now. I should think if you would crowd that pretty thoroughly as far as it goes, and put concrete in the other spaces, and carry it up, you would have a substantial job of it; and bring the concrete clear above the wood, and if you can exclude the air from the wood, you won't have much trouble.

Mr. Skeels.—You better build a new pier.

Mr. Rogers.—That means tear the bridge down and set it on shore somewhere, and quit business for a month or two.

Mr. Skeels.—That is better than to run a train into the river.

A Voice.—I should not think you would have much decay there, from the conditions you have mentioned. I should think you could depend pretty thoroughly on the soundness of the timbers.

Mr. Rogers—Decay might set in before it was dry. Decay will occur between the degrees of 50 and 120, even when it is wet, if the other conditions are favorable, and while that is perhaps not water soaked, if the piers begin to take in air and create fermentation,—if the upper two-thirds is exposed, would it absorb enough from capillary attraction to keep wet?

A. That would depend on whether the heat and wind evaporated it faster than capillary attraction would bring it up.

Q. Do you think the central portion of the platform, where it is covered with the stone work, being air tight practically,—do you think the air would work into that to any great distance, under the stone work? How long ago was that put up?

Mr. Rogers.—Seven years ago.

Q. How long has the water been low?

Mr. Rogers.—It commenced three or four years ago to show a little bit of a drop, and it has been going down three or four inches every year.

A. My opinion would be that your timber was sound but I would not go to work on it without making a test, which you can do easily by boring in there with a small augur.

Mr. Rogers.—As far as you can reach?

A. Well, you can splice your augur.

Mr. Rogers.—And hold your head under water. There are four to six inches of space between the top of the platform and the water.

A. I think it would warrant the expense of a diver. That is the only way I would see. Mr. Sears ought to know a lot about that.

Mr. Sears.—I don't think he is in any danger if he waits another eight years. It depends on the character of the timber.

The President.—Norway is pretty sappy and it would be the worst timber in Michigan to contend with.

Mr. Kellogg.—Three or four years of exposure of Norway say and I would not give much for it.

Mr. Sears.—I would give more for it in the water than in a sand bank.

The President.—The lowering of the lakes has, I guess, been a surprise to a good many of us. That was pretty thoroughly discussed last September by the Deep Waterway Convention at Cleveland. The means of overcoming it were discussed.

Has anyone anything further to offer on this question proposed by Mr. Hubbell?

Mr. Sears.—If I had that work to do,—if the wood wasn't sound enough to carry the pier,—I would put sheet piling

around there and seal it up, as suggested. I think that is the cheapest remedy for it.

Q. Can beech railroad ties be preserved and made durable by treating with coal tar and creosote, and at what expense?

A. They can be successfully treated with creosote at about $9.00 per thousand feet, board measure.

Mr. Kellogg.—Thirty-three ties in a thousand feet?

Mr. Wells.—In my paper I have taken that up. I have had no personal experience with beech ties, under the treatment of creosote. There are some others who have, however, and whose experience I have and will give you in that paper. I don't think the treatment with coal tar would be of any benefit. It would induce dry rot if the whole tie was covered; that, at least, is my opinion.

Mr Sears has been looking up the subject of ties to some extent. He can probably give us some valuable points on that.

Mr. Sears.—I think your answer is sufficient at this time, Mr. President. You fully answered that.

Q. If railroad ties were dipped in a tank of hot coal tar, and then allowed to dry, would the tar penetrate the wood or not?

A. Not to any great extent. That is taken up in this paper of mine.

ARTIFICIAL PRESERVATION OF TIMBER.

GEO. L. WELLS.

The disadvantages under which people are placed in a treeless country can hardly be imagined by those who have been bountifully supplied with forests. As we are approaching the treeless stage it is well to direct our attention to methods of preserving timber, both artificially and in the forests.

A German official who was sent to this country recently to study our forests and methods of preserving, as well as destroying them, is credited with the statement that unless radical changes were made in our methods, America would be looking to Germany for its timber supply in less than fifty years. He also charges Americans of robbing future generations of their rightful heritage by their wicked waste.

There can be no doubt but that the material progress of this country has been largely due to an abundant supply of cheap timber. Log cabins built with the crudest of tools have been a great factor in our progress, often overlooked. Had men waited until more substantial residences could have been erected, places which now support farms, cities and public works of vast extent and value might still have been a wilderness. Yet these same log cabins sheltered a sturdy population who cut and burned timber of fabulous wealth to prepare land for tillage. Lumbering operations, carried on at the same time, have made such large inroads upon forests that many men have felt great concern, not only from its effect upon floods and drouth, but as to future supplies of timber. We are all well aware to what extent these inroads upon forests have lessened the supply and enhanced the value of remaining trees in Michigan.

Some legislation has been enacted to encourage the planting of trees, but the cutting of trees or preservation of them is still largely a matter of dollars and cents. A holder of tim-

ber lands will not continue to pay taxes and let his invested capital remain longer than he can see a profitable profit in doing so. It is evident that with so many vested rights and conflicting interests among the owners of timber lands, that legislative control of forests is a matter full of vexatious problems.

The enhancing value of timber, which has caused lumbermen to go over the same ground several times, each time taking trees which before were of no commercial value, and in some places even cutting off stumps close to the ground for shingle bolts, has caused engineers and consumers of timber to give attention to the matter of artificially preserving it, when placed for use.

Europeans have given the subject more or less attention for a century, experimenting with most everything there, which has been tried in later years, so that there is really nothing very new about this subject. Lack of interest is the only reason why the subject is not better understood. The early efforts, while successful in resisting decay, were thought to be too expensive and for that reason abandoned.

The Electrical Engineers, in looking about for cheap and substantial materials for constructing conduits or subways for buried wires, have no doubt done more than all others during the last twelve years to increase interest in artificial methods of preserving wood. Railroads have given the matter considerable attention for resisting decay in ties and bridge timbers, and protecting piles from the ravages of *toredo navalis* and *linumoria terebrans* in salt water. A few cities in this country have given the subject some attention for preserving wood blocks for paving; but in Europe creosoted wood paving laid on concrete foundation is the most costly and most prized street improvement.

A tree as it is felled is composed of sap and fibre in varying proportions in different kinds of timber. Sap is found in all stages of consistency from liquid to solid, which chemists say contains, among other things, albumen, sugar, starch, tannin, resin and large proportions of water. It is the unripe part of a tree and therefore the most perishable. The fiber

contains carbon and oxygen in large quantities, and a small amount of hydrogen. When the fibre is separated from the sap it does not decompose.

The cause of decay has been attributed by all investigators to the fermentation of the sap which nourishes the germs of decay, and which in time will not only destroy the sap but the fiber as well Fermentation and decay, as is well known, are promoted when the timber is in contact with air under varying degrees of moisture and temperatures between 50 degrees and 120 degrees F. At high or low degrees of temperature, or when continually soaked in water, wood is practically imperishable.

It has been the aim of all who have experimented with artificial processes for preserving timber to stop the fermentation and kill the germs of decay. Most all materials used have been antiseptics. Short descriptions of the most noted processes will best illustrate these efforts and other items of interest.

Kyanizing was patented in England in 1832 by John Howard Kyan. His process consisted of placing seasoned timber in wooden vats with light strips between the timbers, where they were allowed to steep in a solution containing 8 per cent. of chloride of mercury or corrosive sublimate, one day for each inch of the smallest dimension. It depended entirely upon capillary attraction and timber in which the sap had been allowed to evaporate, to get it into the timber, and then when present the antiseptic qualities of the corrosive sublimate would kill the germs in the timber and those which afterwards came in contact with it. The greatest objection to Kyanizing is the poisonous nature of the chloride of mercury, its action on iron, as well as the general objection to metallic salts on account of their solubility in water, on account of which property they are so easily washed out.

General experience has shown that better results have been obtained when Kyanized timber has been used in dry places, like bridges, where it has been known to last twenty to thirty years, than in moist places like foundation timbers,

railroad ties and pavements. Kyanizing has principally been used in the eastern states in this country.

Burnettizing process was patented in England in 1838 by Sir Joseph Burnett. The earliest method was to steep timber in a solution of chloride of zinc in proportion by weight of 1 of the salt to about 33 of water, in the same manner as that described in the Kyanizing process. Subsequently timber was enclosed in cylinders, steamed and the salt forced in under pressure, as will be more fully described in the Bethell or creosoting process.

Many of the objections which have been found in Kyanizing have been urged against Burnettizing, but Burnettizing is much cheaper. Unfortunately for this process, some of the early work seems to have been hurriedly or improperly done. In one case it was so poorly done that dry rot set in. On the Boston and Albany Railroad Burnettized spruce ties lasted nine years where untreated ties decayed in about five years. On the C. R. & I. P. Railway, hemlock, tamarack, pine and cedar, under this process, were used with considerable satisfaction. The A. T. & S. F. Railroad, some years ago, tried it for ties because it was thought that the dry climate of Colorado, New Mexico and Arizona would be favorable to Burnettizing,* but it was afterwards abandoned for the Wellhouse system which had been previously tried and under which treatment ties were found good after nine years Burnettizing has also been objected to because it weakens timber.

On one of the Southwestern railroads from .70 to .50 of 1 per cent. chloride of zinc is used in treating ties.

In Germany, Burnettizing seems to have met with more success than in this country. On account of Burnettized ties decaying from the outside and creosoted ties from the heart, some of the German railroads used both methods on ties by which means the chloride of zinc could not be dissolved. The Germans use a solution containing 1 part chloride of zinc to 50 parts water by volume, and the work is done very thoroughly, oak absorbing 10 per cent. of its volume of the fluid, beech 19½ per cent. and pine 20 per cent.

*Wm. B. Sears, Chief Engineer F. & P. M., Saginaw, Mich.

On account of the soluble nature of the salt in Burnettizing a number of efforts were made to change it chemically to an insoluble compound. One process, the Thilmany, at one time gained considerable prominence. Thilmany used sulphate of copper (blue vitriol) or sulphate of zinc which was forced into the timber, then after withdrawing that solution from the cylinder, a solution of chloride of barium was forced into the timber for the purpose of changing the sulphate of zinc or copper to the insoluble sulphate of baryta; but some chemists have doubted that this chemical action took place under those conditions. From a recent letter to the writer by G. H. Benzenberg, City Engineer of Milwaukee, the following is extracted: "In 1876 we laid quite a considerable amount of four-inch blocks six inches deep, the blocks having been treated by the Thilmany process. This paving gave us excellent service for ten years, and was finally taken up in the center of the roadway for a width of twenty feet because of the wear of heavy travel instead of deterioration due to decay. The blocks when taken up were apparently as sound as the day they were laid and in some portions of the streets the blocks are still in the pavement next to the curb where the travel has not been so great. I am fully satisfied that if the treatment is thorough and careful, that the extra cost of preparing paving blocks by that process is the most economic investment of the pine block pavement. The trouble here was that they had so much work to do that they became careless in abstracting all sap thoroughly before impregnation was begun."

The Wellhouse process employed chloride of zinc with glue and tannin to prepare the timber so as to retain the salt and the Hagen process used gpysum for the same purpose.

The Boucherie process was used to a considerable extent in France about 50 years ago, but so far as the writer has been able to learn, found little favor in other countries. It depended on vital suction in live standing timber, taking up a solution of sulphate of copper. As it can only be carried on a part of the year and in remote places it would find little favor in this country where lumbering operations are pushed so rapidly,

and especially where logs are transported by floating in streams.

The vulcanizing process treats timber placed in a retort with heat up to 500 degrees, coagulating the albumen, and producing chemical changes in the wood to stop decay. It is also claimed that this process seals the pores. Timber treated by this method has not had the wide application and test of time to prove its efficiency that the older methods have had. As vulcanizing at such a high temperature is a partial distilation of wood, more or less acetic acid would be formed, which would make conduits treated by this method unfit for holding electrical cables, because of the destruction of the lead covering by acetic acid.

Many methods employing charring, carbonate of soda, crude petroleum, arsenic, resin, soap, sulphate of iron, nitrate of silver, lime, salt, and various other substances have been experimented with.

Here in the Saginaw Valley the effect of salt in prolonging the life of timber is quite well known. As chloride of zinc-creosoting process has been used to advantage in railroad ties, the writer can see no reason why chloride of sodium-creosote process could not be used with equal advantage, and at less cost.

The subject of cheap timber preservation seems to have employed about as many, and as crazy a lot of inventors as has perpetual motion, with like results, when homœopathic doses of antiseptics were used. Nothing but thorough treatment with liberal use of antiseptic will do.

The writer's experience has been with the Bethell or creosoting process which was patented by Mr. John Bethell in England in 1838, and has been extensively used ever since. As the creosote was cheaper and more plentiful in Europe than in this country, it was more commonly used there than here until recently.

The general experience with the three leading processes was thus summed up by the late James B. Francis, a past President of the American Society of Civil Engineers, in a discussion in 1885: "There can be no doubt about the preservative effects

in lengthening the life of wood either by Kyanizing or Burnettizing. We have found that Kyanizing answers our purpose the best, and we have followed it ever since. My experience has been long enough to leave no doubt whatever about it; it extends from 1848 to this time (37 years). Creosoting, I have no doubt, is a still more perfect preservative, but the expense and difficulty of doing it, prohibit its use to a great extent. Kyanizing is only a preventative of rapid decay, that is all that is claimed for it; it delays the decay."

The creosote or dead oil of coal tar has become much cheaper since then, now being worth about $9.00 per B. M. for a treatment of 15 pounds per cubic foot.

The process consists of placing the timber, separated by lath, on cars, which are run into a heavy cylinder, and which is closed by heavy cast iron doors securely bolted. Live steam is turned on with a temperature of 225 to 250 degrees F. until the timber is heated through thoroughly, coagulating the albumen in the sap. A vacuum is then formed to extract the sap. The cylinder is then pumped full of the dead oil of coal tar, then, from a measured tank, the required amount of the oil is forced into the timber under a pressure of about 100 pounds per square inch.

The open grain timbers when saturated take about thirty pounds of oil per cubic foot, and is required only in a few cases for piles to be driven in salt water. For other work, from 8 to 18 pounds are required; 12 and 15 pounds being most commonly called for in specifications.

The dead oil of coal tar weighs about 8.8 pounds per gallon. It is obtained by distilling the residual product of coal gas, and is taken off between about 450 to 700 degrees F., which vouches for its non-volatile nature.

It contains among other things naphthaline, carbolic and cressylic acid, strong antiseptics. Besides the antiseptic qualities of the oil it is insoluble and heavier than water and can neither be displaced nor washed out by it. The outside of timber treated by the Bethell process varies in a color from a very dark brown to black, white crystals form on the outside, more so in cold weather than in warm. The dark color does

not extend far into well treated timber. It forms a sort of a thick skin which should not be broken. There is no doubt but that the reason why railroad ties do not last so long as other creosoted timber is because the adz is so frequently used, cutting into ties by wearing of rails and pulling out spikes. Leaving the old spike hole open, leaves exposed places under the skin which are attacked by germs, and which could be materially remedied by painting with the oil or plugging spike holes with creosoted pins.

The best effect is upon the more open grained or cheaper timbers. Michigan Norway pine is admirably adapted to this process.

The general benefits can best be shown by giving different experiences in more or less detail.

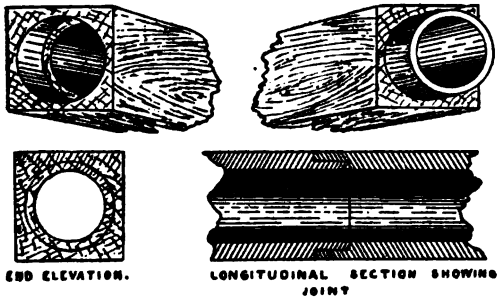
About twelve years ago cities began compelling corporations using electric wires to bury them. Electrical Engineers tried to find conduits for the cables which would be at once cheap, durable and have good insulation. The New York and New Jersey Telephone Company, of Brooklyn, was about the first company to bury their wires, and after due investigation adopted wood treated with dead oil. They now have about 155 miles of the conduit in use. An examination made last summer of the first conduit laid in 1884 showed no signs of decay in the wood nor deterioration in the cables, and has received the unqualified endorsement of that company. This company found that by alloying 3 per cent. of tin with the lead covering of the cables, the covering was not at all affected by carbonic acid and other gasses naturally arising in the trenches and manholes.

A similar experience has been found in Philadelphia by the various light, telephone and street railway companies, and the City Electrical Bureau. There are over 600 miles of conduit used in Philadelphia, most of which has been creosoted. Chicago is beginning to use it extensively. It is being used in a large number of New England towns. A few years after the practice of burying wires was inaugurated, some Boston gentlemen, in order to get conduits at a reduced cost,

had some wooden tubing treated in the south with a compound obtained from distilling wood, and called "Kreosote."

In the distillation of wood, acetic acid is as certain a product as charcoal and this "Kreosote" was impregnated with it. It was found that the acetic acid present in the conduits when laid, attacked the lead covering of the cables, reducing it to acetate of lead. The carbonic acid gas arising from the trenches, again liberated the acetis acid, and this sort of perpetual motion was kept up until the cables were destroyed. An attempt was made to stop the chemical action by injecting asphaltum dissolved in bisulphide of carbon into the conduits. The æsthetic nostril of the residents of the "Hub" were so offended that they at once sought an explanation from the man who had the matter in charge. Unfortunately for him and his scheme, too, he was afflicted with an impediment of speech which added to the complications to such an extent that the poor fellow had to leave town to escape being mobbed. It was some time before the actual cause of the trouble became generally understood. Firms who manufactured conduits of other materials, took advantage of this mishap and circulated the story industriously, seeking to confound the compound obtained from distilling wood with dead oil of coal tar, which is not only a preservative of wood, but of metals as well.

The same company who had this unfortunate experience are now using large quantities of conduit treated with dead oil of coal tar. The American Bell Telephone Company (the parent company) have endorsed it after a thorough investigation.



The usual form of the conduit is square 4½x4½ inches, 4x4 inches, 3½x3½ inches and 3x3 inches with holes 1½ inches less in diameter. The lengths are 8 feet and are jointed with a mortise and

tenon joint as shown in the cut. They are laid on creosoted boards usually 1½ inches thick for a foundation, and are covered by a creosoted board to protect them from blows of tools in hands of workmen employed in subsequent improvements.

Creosoted telegraph poles* in England showed no signs of decay after 35 years, and in Mississippi creosoted poles in use 15 years showed no signs of deterioration.

Poles driven in salt water have been treated with dead oil of coal tar to repel the attacks of the *toredo navalis* and *limnoria terebrans*. If enough oil is injected the protection is permanent, but this hardly interests us who live on unsalted seas.

Railroad ties treated with the dead oil of coal tar have met with a great deal of success in this country and Europe.

In answer to circulars sent out by Mr. Bogart, when Secretary of the American Society, it was found that many ties were sound after 22 years' use. In this country 19 years seems to be about the average life of well treated creosoted ties.

The following is extracted from a letter under date of December 2nd, 1895, from Mr. R. Montfort, Chief Engineer of the Louisville & Nashville Railroad company. "We still have a large amount of creosoted timber on our New Orleans & Mobile Division which was put in during the later seventies, (began in March, 1876),† with the exception of a small number of bridge ties which rotted and were removed the last year or two. Practically all the creosoted timber is still sound. The rotting of the ties is largely due to the fact that we changed the gauge of the track from five feet to four feet nine inches, thus cutting up the ties with additional spikes and allowing water to get into the old spike holes; and also to the fact that the rail has cut into the ties, due to the traffic."

These ties were treated with 15 to 16 pounds of oil per cubic foot, and most of them showing 18 to 19 years' use, and are still serviceable.

On the Central Railroad, of New Jersey, during the year 1876 they put about 5,000 creosoted ties in their main tracks,

*N. W. L. Brown in Electrical Railway Gazette, Oct. 19, 1895.
†Proceedings Am. S. C. E., June 1885; p. 335.

west of Bound Brook. None of these ties were taken out until the year 1888, when about ten per cent. of them were removed. * * * * They experienced no particular trouble on account of spikes not holding. The last of the ties were taken out last summer. Here is about 19 years' use.

It has been found in railroad work that timbers treated with the dead oil of coal tar are not weakened.

The application of the Bethell process to paving blocks seem to have been beneficial. Paving blocks cut out of timber from which the sap wood has been removed, because of being softer than the body wood, and laid with close joints has given good results. Concrete foundations are desirable.

The following is taken from a letter from Mr. B. M. Temple, City Engineer, of Galveston, Texas, under date of December 25th, 1895: "In 1874 several blocks of creosoted short leaf pine sawed block paving was laid on the principal street here, and is in perfect repair and condition. I saw some of the blocks split open last spring and they were perfectly sound. Wedges were used in that pavement but several miles have been laid recently without wedges. The Island being composed of fine sand forty feet in depth, the blocks were laid directly on the sand after it was thoroughly wetted down.

"The recently laid blocks are of long leaf pine and all the blocks are laid 6x6 inches—I do not know how much oil was put in the blocks, having only been City Engineer since last June. I have lived here since 1877, engaged in constructing railroads."

The writer has one of the blocks from Galveston, which is in perfect condition as far as decay is concerned, and shows only half an inch wear. This short leaf Texas pine has the reputation of decaying in two years in its natural or untreated state.

The following is from a letter dated December 6th, 1895, from I. D. Fletcher of New Orleans, a manufacturer of chemical products of asphaltum and coal tar: "Seventeen years ago we paved the roadway of the N. O. Gas Company with creosoted wood blocks and they are as sound as a rock to-day.

"This pavement has had more traffic over it than any other street in the city, as there has been almost a continual line of carts loaded with coal going over it every day since put down. A few months ago we took up some of these blocks to put in our exhibit at the Atlanta Exposition, and found them as they were the day they were put down, except about ¼ inch worn off the top from friction of the cart wheels.

"In answer to your questions, will say, blocks should be treated with about 16 pounds of oil to cubic foot. Size used, 4x6 inches, 4x4 inches and 3x4 inches. We have used long leaf yellow pine to best advantage. For block paving, the heart only should be used on account of its standing wear better than sap, but for post and piling, sap is better because it takes more oil. Blocks not creosoted last about two years."

At the risk of departing a little from his text, the writer has thought it best to collect and give some information on creosoted wood paving, which sometimes deals with comparisons of stone and asphalt.

Birmingham, England, had 169 miles Macadam, 28 miles granite, and 7 miles of wood pavement of creosoted yellow deal (pine) blocks laid on foundation of Portland cement.*

Creosoted blocks are laid on concrete 6 inches to 9 inches thick (7 broken brick or slag; 1 cement), finished off with a smooth, clean surface upon which the blocks are laid without sand or ashes. Double layers of planking crossing each other diagonally have been tried and abandoned. The blocks are creosoted yellow deal 6 inches deep by 3x7 inches, laid in courses ¼ inch apart, blocks having butt joints longitudinally. Spaces between courses are filled with grout of 1 part Portland cement to 2 parts of sand.

The traffic of Birmingham is so heavy that blocks wear out before decay sets in. Street grades are too heavy to admit of the use of asphalt.†

DUBLIN, IRELAND.—The paving in Dublin is mostly stone, but in the principal thoroughfare, which is narrow, and in a few others, the pavement is wood. Wood paving is also used

*Special Consular Reports, Streets and Highways in Foreign Countries.
†W. S. Till, C. E., City Surveyor, Birmingham.

opposite a large number of churches and hospitals to avoid the noise of traffic, in preference to other forms of street paving. Archangel red blocks, 5″x9″x3,″ containing 10 pounds of dead oil of coal tar to the cubic foot, have given the best satisfaction. The foundation is concrete (6:1). Blocks are laid as closely as possible to maintain straight joints throughout. Into the lower half of the joint is poured a hot mastic of creosote, Limmer rock asphalt and coal tar. The upper part of the joints are filled with liquid cement grout (1 cement; 3 sand). The foundation is allowed to stand seven days before the blocks are laid, and the whole finished pavement stands another period of seven days before the street is opened for traffic.

As is generally the case in Europe, the paving wears out before any signs of decay set in. Here, the time is from 8 to 12 years.

Beech blocks were tried, but found to decay because the timber was not felled in the proper season and decay set in.

"I think there are many considerations, such as the effect of climate, difference of traffic, local causes and regard to cost, which must render wood pavements more desirable in some cities than in others."*

The writer is of the opinion that had the beech blocks been steamed, as is the practice in the United States, and the oil forced into the blocks under pressure, this would not have occurred. In applying oil to timber by absorption, there is always the danger that the blocks have not been properly seasoned and dry rot might take place.

FRANKFORT-ON-THE-MAIN, GERMANY.—In Frankfort-on-the-Main, the "Zeil," the principal thoroughfare, was partially paved with wood, German beech and pine, Swedish Pine, American cypress and pine, free from sap, a part of which were impregnated by different methods and part not impregnated at all, and laid on a solid impervious concrete foundation, have given uniform success.† The work was all well and thoroughly done, and while it speaks well for wood pavements

*Spencer Aarty, City Engineer and Surveyor, Dublin.
†Special Consular Reports, Streets and Highways, &c.

generally, the information as to any preserving process is indefinite.

Herr Heinrich Lonholdt of Frankfort-on-the-Main, believes that creosote oil is the best preservative of wood, but that "pickling" answers every purpose. Herr Lonholdt is connected with the "system-Kerr," a German paving, using wood blocks "pickled" in creosote. He has expressed an opinion that Michigan pine is well adapted for paving.

HULL, ENGLAND.—"Granite and wood pavements and Macadamized roads are used in city and districts."

"In wood pavement, which gives much satisfaction in this country, a foundation of cement concrete is formed, 7 inches in thickness, composed as described in granite pavements." Blocks are of red wood sawed square, 9″x3″x5,″ the grain of the wood running with the 5 inch measurement. Courses are laid ⅜ of an inch apart, held apart by lath. Joints filled up with shingle to a level of 1 inch below surface, and remaining space filled with asphalt.

LIVERPOOL, ENGLAND.—This city had in December, 1895, 13,236 square yards of creosoted Baltic red pine, elm, greenheart and pitch pine pavement. 1,367 square yards of creosoted Baltic red pine laid in 1875, on which there was an average traffic of 302,000 tons per yard width, per annum, will need to be renewed shortly—a little over 20 years' use.

4,250 square yards of creosoted Baltic red pine laid in 1874, on which there has been an average traffic of 94,000 tons per yard width per annum, will require a large portion to be renewed—over 21 years' use.

Creosoted elm wears out in Liverpool much faster than the Baltic pine, it having lasted 10 to 13 years. The life of pavements depends entirely upon the amount of traffic. Blocks are 3 inches thick, 9 inches wide and 6 inches deep, and creosoted with 10 pounds of dead oil of coal tar per cubic foot of timber.*

KENSINGTON, LONDON, ENGLAND.—"All the main roads are paved with wood except about 1,000 square yards of asphalt.

* H. Percy Boulnois, City Engineer, Liverpool, England.

The whole of the wood pavement is laid on a foundation 6 inches thick, of concrete composed of Thames ballast and Portland cement, 6 to 1. Over 200,000 square yards of wood have been laid in Kensington, and I* have tried various kinds of wood, including the ordinary fir deals, beech, vale and Jarrah, out of depths varying from 3 to 6 inches, and have laid the blocks in a variety of ways, close together, with open joints grouted with different materials, with felt joints laid on asphalt and on felt, plain deal blocks, creosoted blocks, naphthalized blocks, etc., etc."

About 10½ pounds of creosote is forced into each cubic foot of wood. Streets paved with 5 inch blocks last 10 years. Thinner blocks can be used on the sides than in the centre of the street.

The following table, taken from the report of William Haywood, Engineer and Surveyor, Guild Hall, London, to Consul-General New, on 50 days' observation, shows comparative slipperiness of pavements, showing how many miles a horse might be expected to travel before meeting with an accident:

1. Granite.....132 miles.
2. Asphalt.....191 "
3. Wood.....446 "

London surveyors and Engineers, among other reasons, favor creosoted wood pavements because it is quieter than either asphalt or granite.

Small blocks with close joints give best results for even wearing and cleanliness.

Some pavements are formed of fir blocks 3½"x6"x10" and laid on two thickness of plank well pitched and nailed together.†

"The wood used for paving carriage ways in London consists principally of yellow deal blocks, plain or creosoted, 9"x6"x3," and Jarrah and Karri (Australian) wood blocks, plain or creosoted, 9"x5"x3," laid on foundations of Portland cement concrete (6 or 8 ballast to 1 of cement) 6 inches in

*William Weaver, C. E., Surveyor, Town Hall, Kensington.
†Special Consular reports, Streets and Highways, &c.

thickness, with spaces between the blocks, into which bitumen or grouting is run, and the whole is then covered with a thin layer of fine ballast.

"A cubic foot of yellow deal, cut into blocks, will absorb about 12 pounds of creosote, but the Australian woods, being harder, do not absorb above 6 or 8 pounds per cubic foot. The wood blocks do not decay if properly laid, that is to say, so as to prevent water from getting underneath them."

"It is usual in putting down wood paving, to allow a space of about 2 inches on either side of the carriage way between the blocks and the curb, and which space is temporarily filled in with sand or fine ballast so as to admit of the expansion of the wood after the vehicular traffic is turned on to it."*

MANCHESTER, ENGLAND.—"We have several lengths of street, containing a total area of about 6,500 square yards, paved with creosoted beech blocks. Our specification for the block is as follows:

"English beech wood block, 6 inches to 11 inches long, 3 inches wide and 6 inches deep, the same to be well seasoned and free from sap, and creosoted with 10 pounds of the best creosote oil to the cubic foot of timber.

"The blocks are paved with close joints, on a foundation of cement concrete six inches or more in depth, according to the requirements.

"In this city creosoted beech blocks have lasted about 10 years, and generally speaking, if the blocks are properly creosoted, they wear out before decay sets in."†

In Sheffield, England, some Baltic red timber or yellow deal, free from sap, creosoted with 8 to 9 pounds dead oil of coal tar per cubic foot, laid on concrete foundation, lasted 9 to 10 years. Beech wood had been employed, but was dearer than red wood or yellow deal (pine).‡

Creosoting prevents blocks from swelling when laid and subjected to heavy rains. The sizes of blocks used are 3″x9″x6″ and 3″x8″x6.″ The last dimension running with the grain.

* Alexander R. Binnie, C. E., Spring Garden, S. W. London.
† M. S. Massey, Chief Clerk Department Paving and Highways, Manchester.
‡ Special Consular report, Streets and Highways, &c.

The latter size is used in breaking joints. No spaces are left between blocks now. Each block is dipped 4 inches into a bath of hot pitch and tar and laid and wedged together. Blocks wear out before decay sets in.*

BERLIN, GERMANY.—The pavements lately laid are of Swedish pine blocks, 13 centimeters (5⅛ in.) high, 8 centimeters (3$\frac{1}{16}$ in., nearly,) wide, and 18 to 25 centimeters (7⅛ to 9⅞ in.) long, impregnated with creosote. After treatment they are sorted into three classes. The first class to be used in the middle of the street and where there is the most travel. They are sound and free from sap. Blocks are laid with spaces 8 to 10 m. m. ($\frac{5}{16}$ to ⅜ in.) between them, a lath 8 m. m. being used to get even spacing, but it is removed after the pavement has been laid. When this is done, fluid cement is poured in over them and the top strewn with crushed porphyry. This last process is repeated every four years.

On either side of the pavement, for a distance of 4 centimeters, (1$\frac{7}{16}$ inches), clay is placed, extending to the sidewalk, so that there may be an expansion without bulging of the blocks. Blocks are laid on a concrete foundation 20 centimeters (7⅞ in.) deep.

There are several creosoting plants on the Atlantic Coast and a few in the South. The only one in this State known to the writer, is that of The Michigan Pipe Company, Bay City, Michigan, built under specification prepared by him early in 1894.

No attempt has been made to give numerical demonstrations of the economies derived from using creosoted timber. It is apparent to any observer, and economies can be easily worked out for any particular case or locality.

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*Chas. F. Wike, City Surveyor, Sheffield, England.

NOTE.—The writer of this article has been indebted to the Transactions of the American Society of Civil Engineers, June, 1885, for much of the historical matter and descriptions of some of the processes now obsolete. Other interesting facts have been obtained through correspondence, for which due credit has been given.

SPECIAL ASSESSMENTS--SURVEYOR'S TAX.

E. STRONG.

The object of this paper is to present one method, the form used and object aimed at in that division of special assessments known as Surveyor's Tax.

It will not be claimed that these forms are complete in themselves, or should replace other forms which have long been used with good results. They have been used by the writer and others, for twenty-five years or more, and with complete success in every instance. During my life I have never known of one dollar failing in a Surveyor's Tax.

I have also been unable to find serious legal criticisms pertaining to this tax, after examination of Michigan Reports.

I once heard a circuit judge refuse to entertain objection to a tax title deed because it was based on a Surveyor's Tax. And the court made the further statement that the legality of a Surveyor's Tax had often been tested in the supreme court, and had never suffered an adverse decision, and was just as legal as a supervisor's tax and for the same reason, because it was provided for by statute.

I have known another case of 160 acres of land to be sold to satisfy a Surveyor's Tax of six dollars. This was approved and returned by the Auditor General, the land was bought by a stranger, and ten years elapsed before it made trouble.

The chief reason to justify a Surveyor's Tax, to collect a private debt, seems to be that the statute requires the surveyor (at least the old law did) to perform the duties of his office when application is made to him by any court, or any officer of the court, or any other person. To compensate for this last requirement, it has seemed to me, the surveyor was

allowed to certify his bill to the supervisor. In Public acts of Michigan, 1895, the words "any other person" were omitted.

Two months ago a man, notorious for never paying a bill, applied for a line between himself and neighbor. The surveyor objected for financial reasons. He said: "You have got to come, anyway." The reply was: "I suppose I have." He has not yet paid his taxes, but he will.

PETITION.—A written application and notice of ten days are unnecessary when the parties are all present in the survey, or present in the petition, or consent in other ways. Of course, this condition exists when only one or two are interested. But in case of a neighborhood quarrel a survey to tax should be made with more caution.

Petitioners are required to give notice, but it is better for the surveyor to take names and addresses and notify all at once by mail, keeping a record of the same, and filing the petition. Notice is required only to those living in the same township, but sound sense will give everybody notice. Even when there is no tax, the surveyor should ask to have others notified.

When the owner of a single piece of land applies and neglects payment, I suppose the tax is good, especially if it cannot be collected in a different way. But I have never assessed the platted lots of a village. Unless requested to put it in the tax, the surveyor has also a right to bring action for debt. But it would seem that the statute gives the petitioner *the right* to pay his bill in his tax, if he requests it, and I doubt whether he can be deprived of this right.

If the tax is not spread the following last Wednesday in September and the land is sold to other parties, the levy cannot be enforced. However, it will probably be collected and that will be the end of it.

By permission of the supervisor I have put in a bill as late as November 11. And many times a small tax has gone over two or three years and will make no difference, unless in the meantime the land has changed hands. In one case last year a piece of land was divided into three parts, and deeds given immediately after. The parties agreed among themselves to

furnish the help and the seller was to pay the survey bill, but some time after declined to do so. This bill went in the first year, and was an injustice to the buyers. It certainly could not go in the second year.

If application is made to the surveyor and he is requested to apportion and tax, he has no discretion in the matter and must do so. Neither has the supervisor any discretion. His duties are simply clerical, and he cannot look behind the surveyor's certificate and assessment roll. However, he is very apt to do this very thing; not because he is well posted, but because he knows nothing about it. The surveyor must treat this thing very leniently, answering questions fully, whether proper or not, and making the further statement that the tax is all right, and that the surveyor and not the supervisor is responsible for it. In all cases, reference should be given in the warrant to the statute under which he acts.

One supervisor the past fall on receiving by mail a bill to spread, said: "Why! is it not an unheard of thing that anybody in the world can send a bill to the supervisor and have it put in the tax? Where do you get your authority for any such thing?" The surveyor replied that in the warrant itself, reference was made to the statutes providing for it. After looking it up he said it was all right, but a new thing to him. "But why should the surveyor be allowed to collect *his* bills in the tax any more than doctors or lawyers?" The answer given was that service was compelled where pay could not be collected in any other way, and the statute saw fit to provide this relief. It is also a benefit to the public to equalize the cost of the subdivision of land and not compel the few to furnish the boundaries to others.

He also learned that there was one tax that did not come to him through the township clerk.

Apportionment has been discussed by this society in previous years. The statute requires it to be made in the proportion to the work done for each description, to be determined by the surveyor. But method and practice varies widely in its details. Some have apportioned evenly between the parties; and it cannot be denied that there are many cases

where this is right, probably one-half of all. Sometimes it can be based on acreage; other things being equal, this will answer. But they are likely to be unequal. Others apportion according to work, and acreage and numbers to pay, are important factors in the problem. But the problem is by no means a difficult one. It matters little by what mental process the result is reached in each case. As to myself a random line is run and then corrected. By this I mean an offhand apportionment, covering the bill. Then take from one piece and place upon another, until the roll is equalized.

ORDERS The law of 1895 makes it the duty of the surveyor to draw orders on the county treasurer for himself and others. Heretofore orders were given in the same way, on the township treasurer, without the law expressly saying so. These orders were placed on the same sheet as the assessment roll of the surveyor. And the book of the treasurer should show the same thing. It does not always do so and a new township treasurer is likely to ask for an order from the township board, or clerk, or somebody, and the surveyor will find it necessary to talk a spell, or go home without his pay. He will not easily believe that the surveyor can draw his own order, and spread his own tax, and that, too, without review, and without reporting it to the township clerk. I acknowledge that it is an anomaly in the way of taxation. But the law of '95 has done away with this uncertainty, and placed in plain language the practice of former years.

It has done another very excellent thing. Heretofore, the surveyor has been obliged to go after his pay. No matter how far away the township and treasurer, he must hunt him up and if gone from home, wait his return. Thus, if the bill was small, he earned his money the second time, or let it go altogether. Hereafter, the surveyor will draw his order on the county treasurer, once for all, thereby saving time and breath. (Some bad breath). This is the most important change in the law of recent years, and every surveyor in Michigan will take pleasure in making use of this provision.

ITEMS OF THE BILL TAXED.—Discussion in this society will develop the fact that there is some difference in practice

among surveyors in the items of the bill taxed. His time at four dollars, the time of the chainmen at local rates, the record of each description in the land surveyed at 25 cents each, will not lead to any serious disagreement. But when it comes to 25 cents, also, for each corner established or perpetuated and recorded, there is a chance for a question. So far as I know, this is the practice in our own and adjoining counties. One counts the planting of a stone because he has established a corner, and another man counts it because he calls it a record. Perhaps both are right. I do not know.

The pay of other helps than the chainmen should not go into the bill. I understand that the courts have quite uniformly drawn a line of distinction between chainmen and other help. Someone may be able to show that the courts do no such thing. I should like to know.

One sample of a section surveyed and taxed under petition for the same is given below, with the form of petition and warrant or certificate. Also the items of the bill, together with the apportionment, names and orders. This sample is given to present one case in full, right or wrong. Approved or criticized, it is of no account in itself, but inexperience may prize it.

PETITION.

We, the undersigned, a majority of the resident owners of land on_____, Section_____, in the Township of_____, having given ten days' notice to all other persons, or to their agents, owning land in the same section, who reside in the township, desire you to locate and establish our corners and lines in accordance with the statute in such case provided.

ITEMS OF BILL.

Time, 3 days	$12.00
22 corner stones @ .25	5.50
Moses Osborn, 2½ days	5.00
Allen Owen, 2½ days	5.00
May 2, Searching Records	2.00
13 Records @ .25	3.25
Total	$32.75

CERTIFICATE.

KALAMAZOO, Sept. 1, 1893.

_ _ _ _ _ _ _, Supervisor Township Texas.

Dear Sir: There are due me the following sums of money for surveying lands in your township. I have apportioned the same as required by law (see Session Laws of '71 and '69) at the request of the parties employing me. I shall be entitled to have the same levied and collected on the within described portions of land.

SURVEYOR'S TAX, SEC. 16.—APPORTIONMENT.

Powers, Mrs.	
53 a, n ½ of n e ¼	$ 3.80
Root, C. C.	
40 a, e ½ of s ½ of n e ¼	2.88
and n e ¼ of s e ¼	.57
Britton, B.	
32 a, w ½ of s ½ of n e ¼	2.30
Harvey, P. N.	
34 a, n w¼ of s e ¼	2.45
Kelley, K.	
17 a, s e ¼ of s e ¼	1.23
Parsons, W.	
35 a, s w ¼ of s e ¼	2.52
Conlon, P.	
58 a, n e ¼ of s w ¼ and	
s e ¼ of s w ¼ except 22 a	4.17
Hanna, J.	
57.10 a, s w ¼ of s w ¼ and 22 a of s e ¼ of s w ¼	4.10
Harvey, C. A.	
40 a, n w ¼ of s w ¼	2.88
Harvey, J. 39 a	2.40
Crandall, Mrs. Chas. 33 a	2.50
Stratton, M. B. 10 a	1.00
Total	$32.80

ORDER.

The treasurer is hereby directed to pay from this fund without further order from me to, M. Osborn, $5.00; Allen Owen, $5.00. E. STRONG, County Surveyor.

LEGAL DECISIONS.

BOUNDARIES.

1. Where adjoining owners erect buildings with reference to the supposed boundary line between them, there is a practical location of such boundary.—[Ford v. Schlosser (Com. Pl. N. R.) 34 N. Y. S. 12.

2. Where owners of adjoining tracts plat them with reference to a certain line, which they recognize as a section line, the boundaries of the streets and lots so fixed will not, more than 50 years thereafter, be disturbed, though the true location of the section line be other than that recognized.—[Butler v. City of Vicksburg (Miss.) 17 So. 605.

3. Where the monuments established by a plat are those fixed by the government survey, and those making the dedication in the actual location of the lines of the plat included within the lines of private property a strip of land which, according to the true location, is within the boundaries of the street, the government monuments prevail.—[Brown v. City of Carthage (Mo. Sup.) 30 S. W. 312.

4. In case of a disputed boundary line, where the plaintiff's field notes call for a line the location of which subsequent surveys have changed, and also for a corner which corresponds with the later location of such line, and with calls for distance and other surveys, the first-named call must yield.—[Layton v. New York & T. Land Co. (Tex. Civ. App.) 29 S. W. 1120.

5. The official plat of a township showed that sections 23 and 26 are fractional, bordering on a river on the west; that a meander line runs through them; and that the area of certain lots in such sections is 170.42 acres. In fact, along such meander line is a bayou, west of which, between it and such river, is a body of land over a mile wide, containing 600 acres, which was never surveyed. The length of the section line between such sections, from the east line thereof to the meander

line, is given on such plat as 30.55 chains, while the distance from such east line to the main body of the river is about 1½ miles. *Held*, that such bayou, and not the main body of the river, is the boundary of such sections and lots, and that a patent of such lots "containing 170.42 acres, according to the official plat," did not convey the land between the bayou and the main body of the river.—[Horne v. Smith, 15 S. Ct. 988.

6. The owners of city lots had for 35 years maintained a fence between their lots and the street, and the city had acquiesced therein. The marks of the original survey having been destroyed, a resurvey was made on the theory that the original survey was wrong, and should be corrected. *Held*, that the fence was better evidence than the resurvey as to the location of the line between the lots and the street.—[City of Mt. Carmel v. McClintock (Ill. Sup.) 40 N. E. 829.

7. In locating the northwest corner of a section of which the northeast corner can be located, it is error, instead of merely following the calls of the division survey of the township, to start from a subsection corner in an adjoining township subdivided under a different survey, and thence run a mile and a half, only connecting the subdivision surveys of the two townships by assuming that their section corner stones on the township line coincide.—[O'Hara v. O'Brien (Cal.) 40 P. 423.

8. A deed conveying land bordering on a stream, and defining its boundaries as "commencing at the intersection" of a certain ditch "with the shore line," and extending by courses and distances named to the "S. shore" of the same stream, "thence along said shore as it winds and turns to commencement," made the shore line the boundary, and did not convey the land lying between the low-water mark and the thread of the stream.—[Freeman v. Bellegrade (Cal.) 41 P. 289.

9. Where a fractional lot is conveyed, the grantee is bound by the distances given, even if reference is made to an official map.—[Hostetter v. Los Angeles Terminal Ry. Co. (Cal.) 41 P. 330.

10. Where land conveyed forms a triangle, and two sides and the acreage are given, a straight line from point to point will be adopted as the third side, when the boundary thus formed will enclose the number of acres called for.—[Hostetter v. Los Angeles Terminal Ry. Co. (Cal.) 41 P. 330.

11. Where three sides and the number of acres are known, and it is disputed whether the fourth side is a straight or meandering line, the straight line will be adopted, when the tract thus enclosed contains the number of acres called for, and when the acreage would be largely increased if the meandering line were adopted.—[Hostetter v. Los Angeles Terminal Ry. Co. (Cal.) 41 P. 330.

12. A meander line merely determines the sinuosities of the stream or body of water, and is not a boundary.—[Schlosser v. Crookshank (Iowa) 65 N. W. 344; Caldwell v. Jackson, Id.; McNary v. Same, Id.

13. In the absence of evidence of a reservation in the patent or an assertion of title by the government to land lying between the meander line of a lake, as established by its surveyors, and the shore line of the lake, evidence aliunde is inadmissible to show that the meander line was intended as the boundary of the adjoining patent.—[Schlosser v. Crookshank (Iowa) 65 N. W. 344; Caldwell v. Jackson, Id.; McNary v. Same, Id.

14. Where parties by mutual agreement fix a boundary line, and thereafter acquiesce in the line so established, such line will be considered the true line, though the period of acquiescence be less than that fixed by statute for gaining title by adverse possession.—[White v. Peabody (Mich.) 64 N. W. 41.

15. Where there is a conflict between field notes and the original monuments, the field notes must yield to the monuments.—[Robinson v. Laurer (Or.) 40 P. 1012.

16. Where stakes are found at points so as to conflict with the field notes, the burden of showing that the stakes were monuments of the original survey is on the party claiming to the stakes.—[Robinson v. Laurer (Or.) 40 P. 1012.

17. When a southern boundary is described as beginning at a certain corner, and running "thence east to the southwest corner of the land of C.," such corner becomes a monument of description; and, if its location is definitely ascertained, the boundary would be indicated by a straight line running from the point named to the southwest corner of C.'s land, though the line would run in a southeasterly direction, and the quantity of land conveyed would be about 35 acres, instead of 30 acres, more or less, as given in the conveyance.—[Abbey v. McPherson (Kan App.) 41 P. 978.

18. That a fence is on the true boundary line between two farms cannot be shown by evidence that it is in line with fences on adjoining farms.—[Fuller v. Worth (Wis.) 64 N. W. 995.

DEDICATION.

1. User of land for the statutory period as a public highway conclusively establishes dedication of the land for that purpose.—[Campau v. City of Detroit (Mich.) 62 N. W. 718.

2. Where the public has acquired an easement by user in a highway, the listing of the land for taxes and payment thereof by the owner does not effect the rights of the public in the land.—[Campau v. City of Detroit (Mich.) 62 N. W. 718.

3. A conveyance of lots as bounding on a street, laid out over the grantor's land on a public or private plat, but not opened, is, as against the city seeking to take the land occupied by the street for street purposes without compensation, a dedication of only so much of the land occupied by the street, in either direction, as will enable the grantee and his successors to reach some other opened or unopened public way.—[City of Baltimore v. Frick (Md.) 33 A. 435.

4. Where land was clearly dedicated for a street, it was not necessary that it should be accepted by the public, or used for that purpose, within any limited time, in the absence of a condition to that effect; and hence mere lapse of time of 23 years, without acceptance or user, did not constitute an abandonment.—[City of Baltimore v. Frick (Md.) 33 A. 435.

5. The facts that the bed of the street was from time to time dug up for clay, and that a brick kiln was located on a

part thereof for 18 years, did not nullify the dedication.—[City of Baltimore v. Frick (Md.) 33 A. 435.

6. Mere use of a road over private land by the public will not make it a public road.—[Dicken v. Liverpool Salt & Coal Co. (W. Va.) 23 S. E. 582.

7. Where a narrow strip beside depot grounds was unin-closed by lines of the town plat, and several streets opened into it, and lots abutted on it, which, unless it was intended for a street, would have no access to any street except through an alley, there was a dedication of the strip to public purposes, though it was not so designated on the plat.—[Arnold v. Weiker (Kan. Sup.) 40 P. 901.

DEED.

1. Where a deed contains two descriptions, cach com-plete in itself, of the land conveyed,—one of the descriptions including all the land included in the other, and more besides, —the deed passes title to all the land contained in the larger tract.—[Lake Erie & W. R. Co. v. Whitman (Ill. Sup.) 40 N. E. 1014.

2. Where a grantor conveys part of a lot by a deed describing it by metes and bounds, and subsequently conveys the balance of the lot to another, describing it as being bounded by the land previously conveyed, the grantee in the first conveyance is limited to the tract described in his deed by metes and bounds, though less than it was the intention of the parties thereto to convey.—[Probett v. Jenkinson (Mich.) 63 N. W. 648.

3. A deed which conveys 134 acres on the north side of a lot of land, described by its number, district, and county, the lot being by statute a square, is sufficiently certain to embrace such a parallelogram as would result from drawing a line across the lot, parallel with its northern boundary, so as to cut off 134 acres.—[Gress Lumber Co. v. Coody (Ga.) 21 S. E. 217.

4. Where a deed describes land as bounded by a certain alley, declared such by ordinance, and the grantee and other grantees of lots thereon build their fences on the line thereof, and use it together with the public, the grant is to the middle

of the alley, though the city did not work the alley as thus located, and afterwards changed its location.—[Bliem v. Daubenspeck (Pa. Sup.) 32 A. 337.

DRAINAGE.

1. 3 How. Ann. St. § 1740a7, limits the jurisdiction of "township" drain commissioners to the drains lying entirely within the township, and provides that the county drain commissioners shall have concurrent jurisdiction with the township commissioners. Id. § 1740a8, provides that, "in case it is proposed to run a part of a drain through an incorporated city, the whole of such drain shall be constructed * * * by the county commissioners, and wherever the word 'township' is used in this act, it shall be construed to mean 'city,' as the case may be." *Held*, that the county commissioners have no jurisdiction to construct a drain lying wholly within a city whose charter gives it jurisdiction over its drainage.—[Mason v. Detroit, G. H. & M. Ry. Co. (Mich.) 62 N. W. 989.

2. The probate court has no power to review and set aside the verdict of a jury finding that a proposed drain is not necessary.—[Palmer v. Willett (Mich.) 62 N. W. 1027.

3. 3 How. Ann. St. §§ 1740f, 1740f3, 1740h, provide that the drainage commissioners shall make a special assessment roll, and file it in the office of the township clerk, who shall, on or before October 1st, make and deliver to the supervisor a certified statement of the taxes to be raised on the respective descriptions of land, and require the supervisor to lay the matters certified before the board of supervisors. *Held*, that the township clerk and township supervisor cannot refuse to perform the duties prescribed by such statute on the ground that, in their opinion, the assessments would be invalid, because of irregularities in the proceedings to lay out the drain. —[Laubach v. O'Meara (Mich.) 64 N. W. 865.

4. In proceedings for the appointment of special commissioners to determine the necessity of a drain and the taking of private property for the same, where the name and residence of a non-resident owner, who refused to release, are known, notice by publication from which said owner's name was left

out is insufficient to give jurisdiction under Pub. Acts 1893, § 7, requiring the citation to be addressed to such owner.—[Campau v. Charbeneau (Mich.) 63 N. W. 435.

5. Under Act 1885, No. 277, c. 6, §§ 6, 7, 14, drainage taxes, when reassessed, are to follow the course of other taxes, and be collected in the same manner; if necessary, by sale for non-payment.—[Bump v. Jepson (Mich.) 64 N. W. 509.

MUNICIPAL CORPORATIONS.

1. A street was opened 66 feet wide, on which a roadway 38 feet wide was filled in 6 feet above an abutting lot. The owner of the lot constructed a stone wall along the curb line of the roadway, to its full height, and a plank sidewalk over the space between the roadway and his lot. Afterwards he sold the lot to plaintiff, excepting the right of way for the street. A contract, under regular proceedings, was afterwards let to pave the roadway 42 feet wide. Notice was given plaintiff to remove the wall, which she refused to do. The contractor, then, under direction of the city, removed the planks, placed them upon plaintiff's lot, covered up the wall, and paved above it. *Held*, that the city was not guilty of conversion.—[Fuller v. City of Grand Rapids (Mich.) 63 N. W. 530.

2. The resolution of a common council, declaring the paving of a street 66 feet wide to be a necessary public improvement, was silent as to the width of the roadway. The estimate of the board of public works, previously made, specified a roadway 38 feet wide, the width of the old roadway. Before the letting of a contract, new plans were filed showing that the roadway was to be 42 feet wide. *Held*, that the change of the width did not vitiate the proceedings.—[Fuller v. City of Grand Rapids (Mich.) 63 N. W. 530.

3. The determination of the question of the benefit to private property in improving a highway is vested in the municipal authorities, and, in the absence of fraud, their determination is final.—[Shimmons v. City of Saginaw (Mich.) 62 N. W. 725.

4. Under Local Acts 1889, No. 455, tit. 6, § 16, providing that proceedings of the common council shall be matters of

record, and shall not fail on account of any technical error unless the party complaining shall show affirmatively that he has been injured thereby, failure to record proof of publication of notice of hearing on assessments is immaterial, where it is shown that such publication was had.—[Shimmons v. City of Saginaw (Mich.) 62 N. W. 725.

RIPARIAN RIGHTS.

1. A deed conveying land extending to the "shore" of an inland lake imports only a land boundary, and not one by the water of such lake, under which riparian rights would arise. —[Axline v. Shaw (Fla.) 17 So. 411.

2. Under the riparian act of December 27, 1856, the operation of which is expressly limited to those "owning lands actually bounded by and extending to low-water mark on such navigable streams," riparian rights do not exist unless there is an actual water boundary to the land in connection with which such rights are claimed.—[Axline v. Shaw (Fla.) 17 So. 411.

3. The land below high-water mark does not necessarily pass to a grantee of the upland as appurtenant to the latter. —[Axline v. Shaw (Fla.) 17 So. 411.

4. A portion of a fractional section bordering on a navigable stream was washed away by the current. An accretion formed from an island in the river, and extended within the boundaries of the section, but did not connect with the new shore line. *Held*, that the owner of the section had no title to any part of the accretion.—[Cox v. Arnold (Mo. Sup.) 31 S. W. 592.

5. Where the government grants lands on the bank of a fresh-water stream, without reservation, in states where the common law prevails, all unsurveyed islands between the middle line of the stream and the bank pass by the grant, and the riparian owner cannot be divested by a subsequent survey and grant of the islands.—[Grand Rapids & I. R. Co. v. Butler, 15 S. Ct. 991.

6. A conveyance of lands on a navigable stream by a description establishing a boundary line coincident with the

line of navigation conveys the grantor's title to the central thread of the stream.—[Lake Shore & M. S. R. R. v. Platt (Ohio Sup.) 41 N. E. 243.

7. Where two irregular pieces of land lie on the north side of a river running southeast, and are separated by a half quarter-section line running north and south, accretions formed by the recession of the river to the south belong to the respective tracts lying due north thereof, and the division line between the two tracts continues to the half quarter-section line extended.—[McCaman v. Stagg (Kan. App.) 43 P. 86.

8. The fact that the meander line of a navigable lake, as established by government surveyors, did not coincide with the shore line of the lake, will not overcome the presumption that the government, in patenting land adjoining the meander line, intended to convey the land lying between such line and the lake.—[Schlosser v. Crookshank (Iowa) 65 N. W. 344; Caldwell v. Jackson, Id.; McNary v. Same, Id.

9. The fact that the number of acres recited in a government patent corresponds with the quantity within the meander line along a navigable lake will not prevent the patentee from claiming the land between the meander line and the shore line. —[Schlosser v. Crookshank (Iowa) 65 N. W. 344; Caldwell v. Jackson, Id.; McNary v. Same, Id.

10. The owners of land adjoining the meander line of a navigable lake, as established by government surveyors, are riparian owners, and entitled to all land lying between such line and the high-water line of the lake, though most of such land is high, and not subject to overflow.—[Schlosser v. Crookshank (Iowa) 65 N. W. 344; Caldwell v. Jackson, Id.; McNary v. Same, Id.

COUNTY SURVEYORS' RECORDS.

VAN DER GROEF v. JONES et al.

(Supreme Court of Michigan. Dec. 30, 1895.)

RECORD OF SURVEYS—ADMISSABILITY—EFFECT—ADVERSE POSSESSION—ESTOPPEL.

Error to circuit court, Kalamazoo county; George M. Buck, Judge.

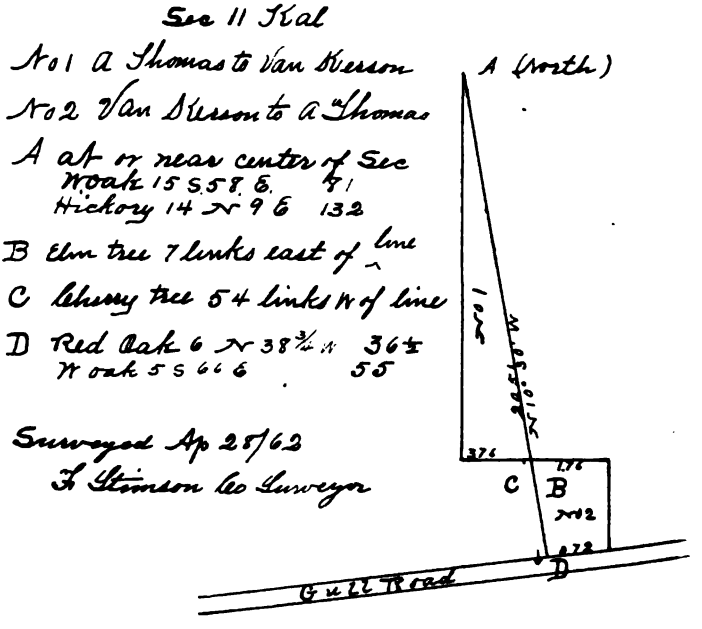
Trespass by Adrian Van Der Groef against John W. Jones and another. There was a judgment for plaintiff, and defendants bring error. Reversed.

H. O. Bliss and Howard & Roos, for appellants. James H. Kinnane and Oscar T. Tuthill, for appellee.

GRANT, J. The dispute in this case arises over the boundary line between the lands of the plaintiff and the defendant Jones, Knowles being his tenant. Their lands are situated in the N. W. ¼ of the N. E. ¼ of section 11, in the township of Kalamazoo. Plaintiff made two claims: (1) That the true boundary line was outside the place where the alleged trespass was committed. (2) If it were not the true boundary line, he had obtained title by adverse possession.

1. Both parties introduced surveys made by competent surveyors. The principal errors arise over the admission of and the effect to be given to a record of a survey found upon the surveyor's record of Kalamazoo county, made April 28, 1862, by the then county surveyor. A copy of this record was introduced, over the objection and exception of the defendants. It will be found on following page.

As to the effect of this survey, the learned circuit judge instructed the jury as follows: "The jury is instructed that the United States government, in its original survey, fixed the section corners and quarter posts. The division of the section was afterwards done by surveyors, and points established thereon,



from the original corners and quarter posts thereon, and if so done by a county surveyor, and a record made by him thereof in a book kept by him for that purpose, as required by law, then such recorded survey is evidence of itself, and the points indicated there must be taken as true." After instructing the jury, as requested by the defendants, that the survey made by the county surveyor is of no greater weight as evidence than those of any other surveyors of equal ability and skill, the judge said: "This is true, gentlemen, but it needs this modification, as I have already practically instructed you, whenever a county surveyor is called upon to make what is practically a resurvey. The survey originally made by the county surveyor, having been recorded in the book, must be taken as true and correct, whether it be exactly done according to his mathematical skill, or the mathematical skill of his profession. * * * It appears by the undisputed evidence that in the year 1862 Fancher Stimson, then the county surveyor of this county,

made a survey of part of section eleven, and that by such survey he fixed and established a point he called a 'center' of said section eleven, and noted the bearings of certain witness trees, as required by law. The center of the section, being thus fixed and established by the proper authority, could not afterwards be changed, whether the center thus established was the true geographical center or not; and any subsequent survey should be for the purpose of ascertaining where the original location of this central point was, and not to determine where it ought to have been." Other language of similar import was used. The practical result of this ruling was the establishment of the line as claimed by the plaintiff.

We think the learned circuit judge was in error in admitting this survey in evidence, and in his instruction as to the effect to be given to it, if it had been such a record as the law makes admissible in evidence. The statute upon which the plaintiff relies is as follows: "The certificate of the surveyor, or his deputy, of any survey made by him of any lands in the county, shall be presumptive evidence of the facts therein contained, unless such surveyor or deputy shall be interested therein." How. Ann. St. § 616. Section 619 provides what the record in the surveyor's book shall contain, and, unless those provisions are complied with, the record is inadmissible for any purpose. Smith v. Rich, 37 Mich. 549. The provisions of section 619 will there be found stated in full. The record of surveys in that case was held inadmissible, because, among other reasons, neither of them appeared to be a survey of any piece of land, nor did either show for whom the survey was made, or the variation of the magnetic needle from the true meridian. The record of the survey in this case does not show for whom it was made, nor the variation of the magnetic needle from the true meridian. It contains no statement that point A is the center of the section. It simply says "at or near the center of the section." This expression cannot be regarded as a permanent establishment of the center of the section, binding upon those who are not interested or parties to the making of that survey. It was held in Hess v. Meyer, 73 Mich. 259, 41 N. W. 422, that a law providing that a record

made and entered by the surveyor upon the surveyor's book shall be received as evidence in all the courts of this state did not make a prima facie case, and it was error to so instruct the jury. The record of a survey which complies with the statute now under consideration is undoubtedly presumptive evidence of the facts therein found, and casts the burden of proof upon the opposing party to produce evidence to rebut the presumption. Whenever, however, other surveys are introduced made by competent surveyors, such survey is of no more binding force than any other, where parties have not acquiesced in it.

2. We think there was ample evidence for the consideration of the jury upon the question of adverse possession. The principles of law in such cases were correctly given, and there was a fair dispute upon the facts. It is, however, claimed on behalf of the defendant Jones that the plaintiff rented some of the disputed land from him, and that this broke the continuity of possession necessary to obtain title, and estopped him to assert such adverse possession. This also was disputed, and upon this point the court clearly instructed the jury that, if they found the fact as claimed by the defendants, the plaintiff had obtained no title by adverse possession. When the defendants removed the fence from the land as claimed by plaintiff, and where it had existed many years, and built it upon the line as claimed by them, the plaintiff said he would have a resurvey to determine where the real line was, and would not abide by the survey which they had caused to be made. Such statement did not estop him from setting up, upon this trial, adverse possession. It was not a conclusive assertion that he did not rely upon it. The judgment must be reversed, and a new trial ordered.

McGRATH, C. J., did not sit. The other justices concurred.

MICHIGAN ENGINEERING SOCIETY.

THE SAGINAW CONVENTION AND BUSINESS MEETING.

The 17th Annual Meeting of the Michigan State Engineering Society was held in the parlors of the Vincent House, at the city of Saginaw, January 7, 8 and 9, 1896.

The Convention was called to order, Tuesday afternoon at two o'clock, by the President, Mr. Wells, who introduced to the Society Mr. William B. Mershon, Mayor of the city of Saginaw. Mr. Mershon welcomed the members to the city in the following words:

MR. CHAIRMAN, AND GENTLEMEN:

It struck me, as I was sitting here, that in view of the reputation Saginaw has had for being a loud and boisterous city, it would be a relief to welcome as quiet and orderly a body of men as you all have appeared to be for the last four or five minutes.

I attended a meeting of lumbermen in Buffalo a few months ago, and Mayor Jewett, of that city, welcomed the gathering and extended to them the freedom of the city, and I at that time, thought he did it very nicely, and I wished that I were gifted with his power of expression, that I might welcome such organizations to Saginaw whenever it should be my good fortune to do so. He dwelt upon the good points and many advantages of the city in which he was mayor, and when he had finished, I think every man in the room had made up his mind that Buffalo was about the best city in the universe.

Now, I cannot, I know, create that impression in regard to Saginaw, as much as I would like, but I do think our city has a good many good points, and the engineering department of the city is to blame for many of them. We are dependent upon our city engineer, as you know, for our good streets—which unfortunately are covered with snow at the present time, so you cannot judge of them.

We are also blessed with what is, I think, the best sewerage system of any city of its size in the Union, and Mr. Roberts and his predecessor, Mr. Canfield, have both had a great deal to do with that, and I can assure you, gentlemen, that the sewage always flows toward the lower end of the outlet. It is a great success in that respect.

Another system recently introduced here is that of tile drains vs. open ditches in our streets, and we have had to fight that tooth and nail for many years, but at last we are successful, in a measure, and I do not think the people would for a moment go back to the old system of open ditches.

The water-works system is complete, considering the source of supply. It affords splendid fire protection, and take it as a whole, I think Saginaw is a city of which I can be proud to be mayor, and that being the case, it is with good grace that I welcome you, gentlemen, to our city, and I trust that your meeting here will abound with the success you anticipate.

I thank you, Mr. President and Gentlemen, for the honor of extending to you this welcome, and I hope that your stay will be long, and I can assure you that your welcome will not be worn out.

(Applause.)

The President.—Permit me to thank you in behalf of the Michigan Engineering Society for the warm, hearty welcome which you have given us.

We meet once each year, in various parts of the state, to discuss topics of interest, not only to the members of the Society, but to the public generally.

From these meetings the profession receives a great amount of good, but the benefit which the public derives from them is immeasurably greater, for by our published proceedings, — scientific investigation and engineering experience, covering a broad field of public works and improvements,—are laid at the very door of every community.

We publish papers and discussions showing where failure and success have been met, indicating to the public how large expenditures of money and annoyance can be saved. We

discuss methods of constructing and maintaining public works with the view of protecting the lives and preserving the health of the people.

As we are bound by no narrow code of ethics, as closed doors and secrecy have no part in our deliberations, as we use only the language which the people understand, and as it is the single aim and purpose of this society to convert the bounties and forces of nature to the use of man, you and the public are most cordially invited to attend all of our meetings.

We especially invite the members of the city government.

I see that the secretary has put me down for an address to the Society and in obedience to his wish, I respond.

(Applause.)

GENTLEMEN:

In opening this meeting I would be ungrateful if I did not express to you my appreciation of the honor you have done me by electing me president of this society. It is, indeed, an honor to be called to preside over a body of men, though numerically small, yet men recognized and honored in the communities in which they live not only for their good citizenship, but for their superior intelligence, learning and industry.

I shall endeavor to show my appreciation of the honor by advancing the interests of the society whenever I have an opportunity, and in carrying out your instructions.

There are some matters of interest to the society to which I wish to call your attention.

The individual efforts of every member is needed to reach that mutual good, which was the prime idea that brought this organization into existence. Every member should contribute his part by preparing papers or discussions to papers read at a previous meeting, securing new and desirable members and increasing our revenues by obtaining advertising patronage for our Annual.

Requests for papers have been promptly responded to by quite a few of the members, but in many instances no responses have been received, while others have declined for a variety of reasons.

Now, we can hardly expect this society to run automatically by an annual winding up by the secretary. I would like to emphasize the recommendation made by Mr. Geo. E. Steele when president, that members send in short descriptions of new methods employed, of new experiences met, etc., without waiting for an invitation from the secretary, and give him notice of it so he can put it in the program, making it bristle with interest.

It is not necessary to write against space,—a half page description of an interesting experience may be just the thing to help out someone.

No two of us have had the same conditions to work under, so each one of us must know something that the others do not, and I wish to impress it that we are entitled *to know* it.

Modesty seems to be a great draw back in getting some members to contribute. Perhaps this can be overcome if we get out some papers in the form of committee reports, so that those who are bashful can hide it more by working with a committee than if preparing separate papers. I believe this matter of taking up subjects for committee reports is deserving of special attention by the society.

There are quite a number of good engineers in the state who are not members and we ought to get them into the society, and every member should constitute himself into a committee of one to urge all engineers who are not on our roll to join.

Our published proceedings cost more money than is possible to raise from membership dues.

We are entitled to a share of the advertising patronage of manufacturers and dealers in supplies which enter into the construction of public works, and we can get it if we ask for it. One man cannot get it all, but if each member would solicit a page of advertising matter from each firm with whom he deals, we will all be surprised at the volume of our revenue and improvement we can make in our already carefully edited Annual.

It is a matter of regret that the rule of the Michigan Railway Association, requiring an attendance of one hundred members to a meeting, has prevented us from securing reduced

railroad fares. We tried hard to get the railroads to grant us a concession in the number of members in attendance to secure the rates, but they declined to do so and in addition to the requirement of asking for one hundred attendance, they asked us five dollars a day for the services of one of their employees to attend the meeting to sign certificates.

It would hardly be within the province of this address to review the changing conditions and lack of employment with which engineers have had to contend the last few years. There is one line of work which will soon engage the services of as many engineers as railroad construction did a few years ago. Most everyone gives the matter some attention. Every one who rides a bicycle has given the subject extra thought. Doubtless horses have given it more thought than their masters. Even the farmers who are far enough advanced to ride wheels think well of it. A small minority of them have long ago figured out the economy of *good roads*. The signs of the times are that good roads are a thing of the near future. In some communities now, there are enough bicyclers who can elect their candidate for highway commissioner. In 1895 demands for bicycles were greater than the manufacturers could supply. In 1896 there will be nearly twice as many factories at work as there were in 1895, besides many old factories have doubled or greatly increased their facilities. This indicates that the annual plowing given highways and the fossilized path-masters will soon be a thing of the past, and scientific road building the order of the day under the direction of intelligent commissioners, and supervision of competent engineers.

The following letter was presented by Mr. Roberts:

R. W. ROBERTS, ESQ., City:

Dear Sir:—I hereby extend, through you, to the Michigan Engineering Society, free transportation over all our lines, during the time of their attendance at their annual convention to be held in our city, next week, and cordially invite the Society to visit our power plant, shops, etc., on any day they may designate.

Members will please present or show their badges to the conductors, which will be sufficient for their transportation.

Very respectfully,

W. J. HART, Gen. Mgr.

On motion of F. Hodgman, the invitation was accepted and the thanks of the Society voted to the company for the courtesy.

The following committees were appointed:

On President's Address—Messrs. Rogers, Sears and Doane.

On Exhibits—Messrs. Hubbell, Rogers and Granville.

On Mr. Barrington's Paper—Messrs. Hubbell, Treadwell and Skeels.

To Secure Advertising for the Annual—The President and Secretary, and Messrs. Sears, Masson, Hubbell, Rogers, Granville, Roberts, Taft, Douglass, Muenscher, Riggs, McVean, G. M. Brown, Ames, G. S. Williams, Dunbar, C. Holmes, Hillyer, and Walker.

On remission of dues in certain cases—Messrs. Appleton, Muenscher, Skeels and Granville.

On donation of reports to certain libraries—Messrs. Treadwell, Vedder and Ames.

It was voted to pay the secretary $125 for services in 1895.

It was voted to submit to the Society by letter ballot an amendment to Article III of the constitution, striking out therefrom the date of the annual convention, leaving the date to be determined by the board of directors. Such amendment was submitted as directed on the first Monday in March.

The following nominations were made for officers for the ensuing year:

For President—Geo. L. Wells.

For Vice President—Frank F. Rogers, G. M. Ames, H. E. Riggs.

For Secretary and Treasurer—F. Hodgman.

For Directors—Wm. Appleton, G. S. Williams, Wm. B. Sears, M. Walker, H. K. Vedder, Dorr Skeels and C. E. Greene.

It was voted that the president appoint a committee of three, to be assisted by Mr. T. P. Whittier, to prepare a model city ordinance for regulating the franchises of electric street

railways, and report at the next convention, or through the next Annual if practicable. The president took time to consider and now announces as such committee: R. W. Roberts, chairman; J. J. Granville and Wm. Appleton.

The local arrangements for the convention were all that could be desired and the Society received a royal welcome from the citizens of Saginaw and the local members. Wednesday afternoon was spent in visiting the works of the Lufkin Rule Company, the Saginaw Brick Company and other points of interest in the vicinity. Wednesday evening, after business was transacted, the doors of the dining room were thrown open and a magnificent banquet was spread and served the Society. It came as a surprise from the local committee, and was highly appreciated.

The remainder of the evening was spent in social enjoyment, stories and music. In appreciation of the various courtesies extended the Society, votes of thanks were extended to the Street Railway Company, the Lufkin Rule Company, the Saginaw Brick Company, the local committee and the proprietor of Hotel Vincent. At the close of the convention the following reports of committees were presented and acted on.

The committee on Questions in Land Surveying made the following report, which was adopted:

MR. PRESIDENT:

Your committee would respectfully report that the following question has been submitted to them: "A section is surveyed and subdivided on application of the resident land owners. Part of the section is non-resident. Do the non-residents receive any benefit from the lines and who is to pay for the same."

We are of the opinion that if the person making the subdivision was County Surveyor at the time of subdivision, that the statute under which he is officiating as County Surveyor provides for his getting his pay, when doing work on proper petition. If the subdivision was properly done, non-residents get equal benefits with residents.

DORR SKEELS,
JOHN RANDALL,
GEO. W. DOANE,
} Committee.

The committee to whom was referred the request of the Grand Rapids Historical Society for a set of our Annuals, and Mr. June's proposition to place such sets in libraries in different parts of the state, reported favoring such action. The report was accepted and the committee discharged. After some discussion, it was voted to place the whole matter in the hands of the secretary for further action, in his discretion. Accordingly the secretary has had six full sets of the Annual bound and has furnished one set to the Grand Rapids Historical Society, one to the Kalamazoo Public Library and one to the Hoyt Public Library in Saginaw. No other applications have been received up to the time of printing this report.

Last year's committee to whom was referred the question as to the *advisability of joining the Association of Engineering Societies* reported adversely. The report was adopted and the committee discharged.

The committee on Mr. Barrington's paper reported it to be a valuable paper in lines similar to those of Mr. Duncan's, read at this meeting. The report was accepted and committee discharged. This paper, together with a number of others which there was not time to read and discuss at the convention, was referred to the secretary for publication in the Annual.

The secretary stated that the papers presented would make the largest Annual in the history of the Society and would be correspondingly expensive to publish. It was a question of dollars and cents. If sufficient advertising patronage could be secured to warrant the expense, all would be published, otherwise something must be omitted.

The committee on the question of remitting dues in certain cases reported in favor of leaving the whole matter in the hands of the board of directors to remit dues in worthy cases, without publicity. The report was adopted and the committee discharged.

The committee on exhibits reported as follows:

Your committee on exhibits beg leave to make the following report:

The tape exhibit of the Lufkin Rule Company is very complete, containing seven varieties of tapes. There are steel tapes in open reels, steel tapes in nickel plated steel cases. These last are of American steel, and very cheap but good, the graduations being the same as on more expensive makes. Steel tapes in the leather cases are made of French steel. They are all made in lengths from 25 feet to 100 feet, graduated either in feet, inches and sixteenths, 10ths and 100ths, or in centimeters. We are especially pleased with the narrow detachable tape, but think we would prefer the open reels to closed cases on account of the liability of rusting, however, we know that closed cases are almost a necessity on pocket tapes. The metallic tape shown is good for many purposes. We make special mention of the novel and improved handles which are a special feature of the Lufkin tapes.

The Bay Port Quarry exhibit contains samples of crushed stone, building stone and stone paving blocks. The Bay Port rock is very tough stone and is said to have a crushing strength greater than granite.

The samples of vitrified paving brick from the Saginaw Clay Manufacturing Company have the appearance of being as good as any paving brick in the market.

The Michigan Pipe Company, of Bay City, exhibit a steam pipe casing—with 4-inch shell, tin lined. Also a creosoted railroad tie, and samples of wood conduit for electric wires treated in the same manner. Also one length of Wyckoff water pipe, which is largely used in Michigan and various parts of the country in water works plants. It possesses the advantages of not rusting and being unaffected by acids which makes it adapted for use in mines, pulp and fibre mills and chemical works. It is banded with a heavy steel band, wrapped spirally from end to end, which band is put on with a machine, insuring good contact. As the wood is a nonconductor of heat, it resists the action of the frost well. These qualities make it well adapted for water works and general purposes.

The National Cycle Mfg. Co. exhibit a bicycle which is neat in design and finish, and has the new features of the 1896

wheel, which are narrow tread and larger tubes—weight 23 pounds. It appears to be a high grade wheel of much merit.

Mr. Whittier exhibits a roller bearing sulky wheel which appears to be much easier and smoother running than a ball bearing wheel which is shown with it.

F. F. ROGERS,
JOHN J. GRANVILLE.

Report accepted and committee discharged.

The committee on president's address reported as follows:

GENTLEMEN OF MICHIGAN ENGINEERING SOCIETY:

Your committee appointed to report on the advisability of our Society appointing special committees to make extended study of various topics of interest to our members, most heartily approve the suggestion of our president and have named the committees to work on the following topics:

1. Committee on Forestry, to study the climatic effect of the removal of forests and to report plans for preserving the same—F. E. Skeels, Grand Rapids; J. J. Hubbell, Manistee; John Randall, Chas. Holmes, Saginaw, E. S.; Henry Melchers, Jr., Saginaw, E. S

2. Committee on Materials for Street Paving; their use and utility, Macadam and subdrainage to be included—H. A. Coller, Grand Rapids; Wm. Appleton, Lansing; R. W. Roberts, Saginaw, E. S.

3. Committee on Relation of Water Supply and Sewerage to Public Health—G S. Williams, Detroit; H. E. Riggs, Toledo, O.; F. F. Rogers, Port Huron.

The committee on Cements being already appointed is not mentioned.

F. F. ROGERS,
WM. B. SEARS,
GEO. W. DOANE.

The report of the committee was adopted.

The annual report of the secretary to the convention was read and approved.

SECRETARY'S REPORT TO THE CONVENTION.

The board of directors of the Michigan Engineering Society met at Hotel Downey, in Lansing, Wednesday, September 18, 1895, at 9 A. M. There were present Directors Greene and Skeels, and Secretary Hodgman and Members Appleton and Sears. Ballots for officers were canvassed and the following found and declared elected:

President—George L. Wells.

Vice President—Frank F. Rogers.

Secretary-Treasurer—F. Hodgman.

Directors—Wm. B. Sears, Dorr Skeels, Wm. Appleton.

The annual reports of the secretary and treasurer were read and approved. They are as follows:

SECRETARY'S ANNUAL REPORT.

TO THE BOARD OF DIRECTORS OF THE MICHIGAN ENGINEERING SOCIETY:

I would respectfully report the following business transacted by me for the Society since the last annual convention:

Immediately after the convention I set about securing advertising patronage for the Annual report, and also got bids from various firms for its publication. It was late before enough funds were in sight to warrant awarding the contract for printing, which was then let to the lowest bidder, Robert Smith & Co., of Lansing. Owing to the desire to keep the publication of the Annual within our known means for payment, some matter was omitted which would otherwise have appeared. Prof. Greene withdrew his paper which was published in the Technic, and will thus reach the members of the Society. Mr. Watkins' lengthy paper on riparian rights was also withdrawn by the author. Mr. Steele's paper on the provisions of the general acts for the incorporation of villages and

cities was received too late for discussion in the convention, and as the acts which it was desired to amend had passed the legislature before the Annual was fairly begun, the paper was omitted. Mr. Barrington's paper on American bridge practice which was not read in the convention for want of time, was held over. It will be ready for use at the next convention if desired, and for publication later. As the printing proceeded somewhat slowly, the secretary continued to solicit ads. until the last moment and enough were secured so that it was not necessary to omit any other papers. 1,500 copies were printed.

Arrangements have been made for the usual exchanges, although there is doubt in regard to the Indiana exchange. That Society published no report in 1894. Early this year I learned from Mr. O'Brien, their new secretary, that the 1894 and 1895 reports would be published together in good season. Since then I have had no reply to my letter to him. I had our reports for that Society sent direct to him from the printers and was recently notified by Smith & Co. that he refused to receive them. I have received the Technic and Technograph, and also the Iowa and Connecticut reports but no others.

Ballots for members were sent out at the proper time and the result of the ballot was announced in the Annual. Two members, Mr. F. H. Williams, of Allegan, and F. S. Bigler, of Detroit, have applied for withdrawal. Mr. Bigler has paid up his dues to date of the application and is entitled to honorably withdraw from the Society. Mr. Williams has not paid up. Mr. Sowter, who applied last year for withdrawal, has not paid up his dues. In the case of S. N. Beden, who was reported last year for two years' non-payment of dues and whose case was then deferred, the secretary learns that he still lives in extremely poor health from which he will probably not recover. I would suggest that it might be appropriate to enact a bylaw under which the directors may have the power to transfer aged members or those who are poor and in ill health from the active to honorary membership, and exempt them from the further payment of dues or assessments.

At the last annual meeting of the board of directors the secretary was directed to proceed to collect from R. C. Pope,

of Chicago, the amount due from him for advertising. The papers were placed in the hands of Martindale & Co., of that city, who, after a liberal amount of dunning, returned the papers and reported the account as worthless.

Ballots for officers were sent out to the members August 15th; also, notifications were sent to all those in arrears for dues. The ballots received are herewith returned to be canvassed.

F. HODGMAN, Secretary.

TREASURER'S REPORT.

During the past fiscal year I have received and disbursed for the Society the following sums:

RECEIPTS.

On hand Oct. 10, 1894	$105.72	
Received for membership fees	23.00	
" for dues	301.45	
" for advertising	105.00	
" from sale of Reports	28.00	$564.27

EXPENDITURES.

Paid expenses of Board of Directors and Secretary	$ 36 79	
" Secretary as voted by Society	100.00	
" Prof. Greene for 1883 reports	24.00	
" H. E. Speir, stenographer	58.20	
" for Am. Digest and Law Reporter	4.25	
" " miscellaneous printing, plates, Annual, circulars, etc.	118.00	
" for postage and envelopes	29.75	
" " express and freight	6.02	
" " copyright	1.00	$378.01
Balance on hand Sept. 18, 1895		186.26
		$564.27

There is due to Robert Smith & Co. for printing the Annuals, ballots, circulars, etc., $152.11.

There is due the Society from advertisers	$115.50		
" " " for Reports sold	24.00		
" " " from members, '95 dues	88.00		
" " " " " '94–'95 "	40.00	$267.50	

Doubtless a considerable portion of this sum will never be paid. So far as cash is concerned, the condition of the Society's finances may be summed up as follows:

ASSETS.

Cash on hand	$186.26	
Due from advertising	115.50	
" " customers for Reports	24.00	
" " members	128.00	$453.76

LIABILITIES.

Bills payable, R. Smith & Co.	152.11	
		$301.65

The Society has on hand a large quantity of Reports, books, engineering papers and instruments of very considerable value of which no inventory has ever been made.

F. HODGMAN, Treasurer.

STATE OF MICHIGAN, } ss.
Kalamazoo County, }

Subscribed and sworn to before me, a notary public in and for Kalamazoo county, this 17th day of September, 1895.

WILBUR C. POND, Notary Public.

It was voted to hold the next convention in Saginaw, January 7, 8 and 9, 1896, and the members living in that city were appointed local committee on arrangements. The question of amending the by-laws to provide for remission of dues in certain cases was presented and discussed. The further arrangement for the convention was left in the hands of the newly elected officers. The board then adjourned.

F. HODGMAN, Secretary.

A special meeting of the board of directors was held on January 9th at Hotel Vincent, all the members being present. Applications for withdrawal were received from F. S. Bigler, F. H. Williams, E. W. Redman and F. A. Rice, which applications were granted.

The membership of Wm. R. Coats was annulled for nonpayment of dues. Applications for membership were received, approved and classified as follows:

FOR SENIOR MEMBERS.

D. A. Brotherton, city engineer, Escanaba; Geo. F. Martin, city engineer, St. Joseph; C. Mason, engineer and salesman, Detroit; V. V. Newell, mechanical engineer, Agricultural College; Byron E. Parks, mechanical engineer, Grand Rapids; C. C. Pashby, instructor in mathematics and civil engineering, Agricultural College; John Randall, now a junior member; S. S. Reed, county surveyor, Three Rivers; F. B. Slocum, sales manager for H. R. Worthington, Detroit; R. C. Smith, civil engineer and surveyor, F. & P. M. R. R., Saginaw; Thos. P. Whittier, manufacturer, Saginaw.

FOR JUNIOR MEMBER.

P. R. Bush, surveyor and civil Engineer, Saginaw, Mich.

Letter ballots were sent out as required by the by-laws and all the applicants elected to membership.

THE TEREDO NAVALIS.

The following statement, by Mr. E. U. Hunt of the Nicaragua Canal Survey, was received too late to be printed in connection with Mr. Wells' paper on the Artificial Preservation of Timber, for which it was intended:

E. U. Hunt.—In Nicaragua the teredo seemed to be in the San Juan river as far up as Machoca Rapids, eighty miles from Greytown, as the Navigation Company had some lighters at that point which they used for taking coffee over the rapids in the dry season, and in one year they were so badly eaten that they were obliged to take them out and put zinc on their bottoms. In the harbor at (San Juan Del Norte) Greytown the teredo ate the piling under the railroad wharf and docks nearly as bad as they did outside in the sea. The harbor is practically fresh water, owing to the light tide and narrow channel and large amount of water flowing through from the river. The river San Juan and Lake Nicaragua are, I believe, the only fresh waters on the continent in which shark abound, and there are plenty of them there, as I have caught them sixty miles up the river.

ERRATA.

In Mr. Wells' article on Artificial Preservation of Timber, page 300, "profitable profit" should read "probable profit."

Page 309, "6x6 inches—" should read, "6x6 inches×—."

MICHIGAN ENGINEERS' ANNUAL.

This Annual publication is the organ of the Michigan Engineering Society and contains the papers read before the Society and the discussions thereon.

These Annuals contain more than 200 papers on matters of interest to Surveyors and Civil and Mechanical Engineers, written by practical men of experience who know thoroughly what they are writing and talking about. Some of the subjects treated are Land Surveys, Railway Surveys, Construction and Maintenance, Easement Curves, Photographic Surveying, Hydrographic Surveying, Cemetery Surveying—plats and records, Village Plats, Map Drawing, Highway Location and Construction, Bridge work, Waterworks, Sewerage, Drainage Engineering, Irrigation, and an extensive digest of legal decisions of special interest to Land Surveyors and Civil Engineers.

This large amount of valuable matter, constituting an engineering education of itself, can be had in no other place or form. The Society offers these annuals for sale at the following prices:

For the years 1880, 1881, 1882 and 1884.....50 cts. each.
For 1885.....75 cts. "
For 1891, 1892, 1893, 1894 and 1895.....$1.00 each.
For 1896.....1.25 "

For the intermediate years the Society has but very few copies left and these will only be sold in full sets. Price of the full sets, 1880 to 1896 inclusive, $12. For sale by

F. HODGMAN, Sec'y Mich. Eng. Society, Climax, Mich.

LIST OF MEMBERS, 1896.

SENIOR MEMBERS.

Allen, Jerome, Surveyor, Milan, Monroe Co., Mich.

Appleton, William, Civil Eng., Lansing, Ingham Co., Mich.

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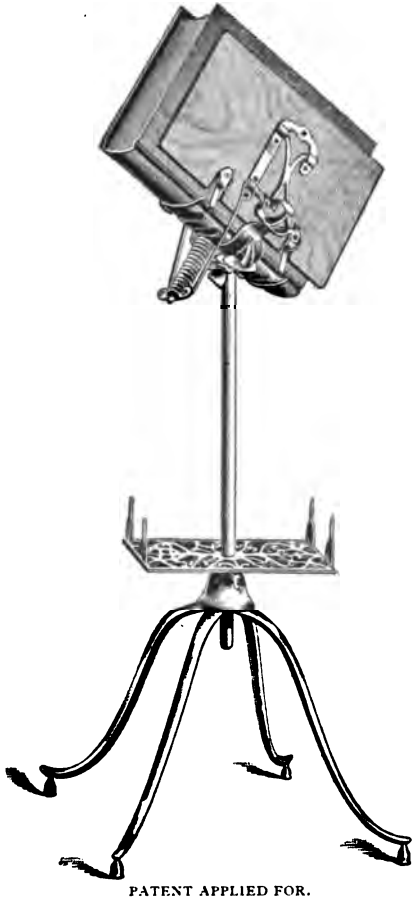

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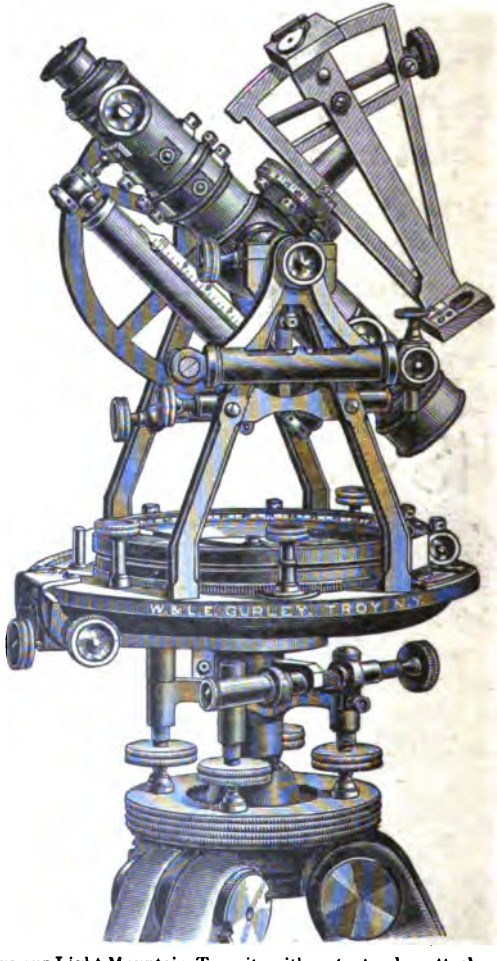

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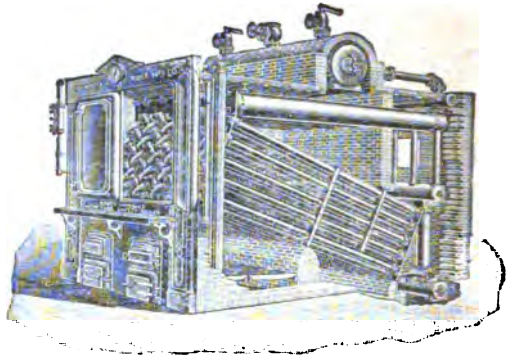

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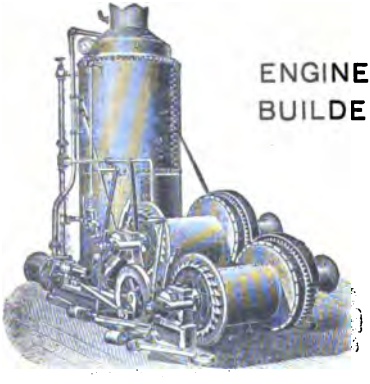

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ANNUAL CONVENTION, 1897

WATER LEVEL OBSERVATIONS ON THE GREAT LAKES.

BY B. H. MUEHLE, U. S. ASST. ENGINEER,
DETROIT, MICH.

The reader of the published proceedings of the Deep-Waterway Convention held at Cleveland, Sept. 24-26, 1895, cannot fail to observe that the all-important question whether the levels of the lakes have been or will be affected by channel improvements and sanitary or other canals has not been definitely answered and is therefore still open for discussion, and the reason is found in the absence of sufficient data or information upon the subject of water levels and their fluctuations in the great lakes.

At the convention several valuable papers were presented and read by eminent engineers, who have expressed strong opinions upon the subject and yet freely admit the insufficiency of proof, a fact which appears from the following quotations:

A board composed of three prominent officers of the U. S. Engineer Corps in a report says: "The supply of water in the lake, the net supply, allowing for evaporation, is the sole cause of the outflow. That supply depends solely upon rainfall, but the lake when it receives more than it has been receiving, must discharge more; when it has less, there is less to run out. If the outlet *be dug down*, or *new ones made*, the water runs off faster than it did before" . . . . . "2. The tapping the lakes must affect their levels." . . . . . "The

board is a unit in suggesting the importance of a series of gaugings of the St. Clair river at the present time for this purpose and to furnish additional knowledge of the relation between gauge readings and discharge. The subject is of such general bearing upon the navigation of the lakes that *it demands careful treatment and full data.*" (Page 359.)

Mr. T. T. Johnston, C. E.: "It is a fact that the hydraulic conditions in the basin of the upper lakes are and have been undergoing a change, the effect of which is not determined and *may never be.*" (138.)

Mr. D. F. Henry, C. E., said: "These fluctuations and changes in the water level enable us to see *how very little we know* about why the water is high at one time and low at another."

Mr. Geo. Y. Wisner, C. E., who advocates regulating water levels by means of a dam at the head of Niagara river, says: "With the data now at our disposal it is impossible to state definitely what may be accomplished by either of these plans." (130.)

Col. B. A. Eckhart in his remarks in defense of the Chicago sanitary canal says: "As it is usual to sustain any proposition with figures, our friends the scientific men come forward with their calculations. If it can be figured out, there can be no doubt of the effect of the channel when completed upon the lake levels. Figures never lie. . . . . But is it known, *can it be known from the data which are at present accessible*, what the actual effect will be?" . . . . . (143.)

Mr. L. E. Cooley, C. E., the originator of the Sanitary canal, concludes: "1. That the *data are insufficient* to reach a conclusion as to the specific effect, and that the information indicates" . . . . . (367.)

Reference is made in the briefs submitted by Messrs. Cooley and Johnson to the attorney of the Lake Carriers' Association to accompanying charts (369) showing monthly means of water level observations on Lakes Michigan and Huron compiled from the records of the U. S. Engineer department, and these charts contain the *only reliable* information in regard to fluctua-

tions of water levels of those lakes which is at present available.

It is therefore important to know in how far these records may be relied upon and used as a basis for determining the specific question whether the excavation of deep channels in the connecting waters of the lakes, or the construction of canals tapping the lakes, are responsible for the prevailing low stage of water, and for this purpose a brief description of the origin and basis of these records may be of interest.

Water Gauges are either stationary or self-registering, but as both answer the same purpose and necessitate the periodical attendance of an observer who records the readings, only the ordinary gauge, which is in most general use, need be described: It consists of a piece of board or plank, one to two inches thick, three to six inches wide and six to ten feet long, which is spiked perpendicularly to the side or front of a dock, wharf, pile revetment or timber crib, about one-third under water and two-thirds projecting above it, and so that it can be seen from a passing vessel or from the top of the wharf, or both. Upon its flat surface are painted or engraved figures denoting feet with intermediate horizontal stripes or notches indicating tenths of a foot. Near the water surface is a 0 or zero, and the feet are numbered consecutively 1, 2, 3, etc., upward as well as downward from this 0. The zero of a water gauge represents a plane of reference established for the purpose of regulating the depth of dredged channels and heights of breakwaters or protection piers in the immediate vicinity, and is intended to indicate mean low water.

In a group of harbors, upon the shores of one or more lakes, or along the shores of a river, gauges are usually set with their zeros to correspond with a common datum plane of reference for such lake or river, and the zero of each gauge is connected by means of levels with bench marks upon the shore, so that if the gauge should be defaced or destroyed another may be readily placed with its zero on the same level as the one which was removed. In order to ensure accuracy in reading the gauges, it is desirable to set them in sheltered places, where the wind and waves cannot reach them, but in a great many harbors such

places cannot be found, so that most of the gauges are more or less exposed.

The observers charged with the duty of reading the gauges are principally inspectors of dredging operations and in some places harbormasters or watchmen. At Chicago, Milwaukee and Grand Haven on Lake Michigan, at Sand Beach Harbor of Refuge on Lake Huron, and at Cleveland and Buffalo on Lake Erie water gauges are read and records kept on every day in the calendar year, while at other harbors no gauge readings are recorded except when dredging operations are in progress or during the time when a survey is being made and soundings taken. At some places observations are made once daily, at high noon, at other harbors three times daily, at 7 a. m., 12 m. and 5 p. m., and during surveys sometimes every hour.

The method of reading a gauge during calm weather is simple, the distance, in feet and tenths, of the water surface from the zero is noted and prefixed by signs indicating that it is above, +, or below, —, the zero or plane of reference. The records of the gauge readings are supplemented by information as to the state of the weather and the *force and direction of the wind. These latter items are of greater importance than is usually ascribed to them.*

When there is a strong wind and consequently high waves, the fluctuations of the water level upon the face of the gauge render a correct reading and the record more or less unreliable. It is assumed that at a point midway between the crest and bottom of a wave is approximately the line of water level, but as successive waves are not of equal height, the mean distance from zero will vary, so that a number of waves must be observed before a fairly correct reading can be obtained. It is doubtful whether in all such cases sufficient time and care is taken to obtain even a moderately accurate record. Hence the conclusion may be justified that the degree of accuracy of all gauge readings during rough weather is proportionate to the fluctuations of the water level caused by waves and the intelligence and assiduity of the observers.

These gauge readings, taken at each harbor and during each month, are then compiled, and the monthly mean stage of

water computed by adding all the readings and dividing the sum by the number of observations; this is intended to represent the average height of the water level of the lakes, rivers or harbors with reference to the zero of the respective gauges. In like manner daily and weekly means are computed when required, also the means of readings during the winter months, called annual mean low water, and the means of readings during the season of navigation, or annual mean high water.

The value of all this statistical information depends upon its application and use. As applied to the question under consideration it is inadequate and misleading, more especially on account of the method of computing averages or means. If these records are to be used in determining with any degree of accuracy the fluctuations of the water level of either of the lakes between successive periods, months or years, or the difference in the water levels between adjoining lakes connected by rivers or the probable causes of the gradual lowering of the lake levels during the last ten years,—a different method of obtaining the desired information should be adopted.

Let it be understood in the beginning that it is desirable to know the height of the water surface of a lake *when it is level* or nearly so, in other words, during calm weather only, and it will be conceded that by simply excluding all water gauge readings taken during stormy weather before the computation of mean water level is made, a very different and more nearly accurate and satisfactory solution will be obtained. The monthly and annual fluctuations of the lake water *when level* should be ascertained and *not* the temporary or transient variations of the surface caused by storms, excessive rains or other local and temporary disturbances. While it may be possible to prepare charts of monthly water levels by this method of computation, using the gauge readings, records of force and direction of the wind as they have been, and are now, collected by the United States Engineer Department, yet it seems that a more uniform system of gauge readings might be inaugurated with a view to obtaining in the near future more accurate information upon the subject.

As long ago as 1860 Mr. Charles Whittlesey in his pamphlet on "Fluctuations of Level in the North American Lakes," wrote as follows: "The Topographical Bureau has required its agents at the lake harbors, in some cases, to keep water tables, and these form the most minute and reliable information we possess. This corps, however, is engaged in harbor constructions only at irregular intervals, and consequently leave in their records many blank spaces. Government has, however, through its lighthouse keepers, the means of procuring perfect registers of water levels on all the lakes, with the least possible expense," etc. The irregularity in the prosecution of harbor improvements, now in charge of the corps of engineers, has continued to date and is caused by biennial appropriations made usually near the close of the first or "long" session of Congress; hence the suggestion of inviting the coöperation of the lighthouse establishment for the purpose of collecting a uniform, continuous and complete record of water level observations is a good one, and might be acted upon at this late day.

In order to obtain uniformity in the daily record of fluctuations every day of 24 hours should be divided into equal periods of say 6, 8 or 12 hours, and observations made at the end of each period. The blank registers of water levels now in use provide for only three observations daily viz.: 7 a. m., 1 p. m., and 7 p. m. These could be changed to 6 a. m., 12 noon, 6 p. m. and 12 midnight, which arrangement would entail no special hardship on light keepers, as their principal duties are performed at night. Three observations may be made at 4 a. m., 12 noon, and 8 p. m., and two observations at 8 a. m. and 8 p. m., so long as an equal number of hours intervenes between them. All gauges should be placed in a locality or position least exposed to the waves, preferably within enclosures or wells, through the sides of which water percolates slowly, so that there be but little fluctuation of the water surface in contact with the gauge, no matter how high the waves may run upon the outside. The direction and force of the wind should be, as now, carefully recorded with each gauge reading, the force to be indicated by four different letters, viz.:

C—calm, L—light, F—fresh and G—gale. In the column of "Remarks" the state of the weather should be noted, whether clear, foggy or rain.

When at the end of each month the registers of all observers along the shores of a lake have been collected, they should be examined together with special reference to the force-of-wind column, and all records of water gauge observations taken during stormy weather, say those marked F and G, *at once eliminated* as unreliable and useless for computation of a mean stage of water in the lake *when level.* The remainder, all the gauge readings taken at the several harbors or stations during calm weather, may then be studied separately and computations of daily, weekly or monthly means made, which will show the fluctuation of the water level to be much smaller than if all the readings had been used in the computations. It will also be possible to find a probable cause for each difference in water levels between successive periods of calm weather by referring to the columns giving the direction of the wind and the weather during both the calm and stormy periods.

Whenever favorable conditions for accurate gauge readings prevail at *all* the harbors or stations of a lake for any length of time, the simultaneous observations taken at each place, when examined together, will furnish more nearly accurate information regarding the actual height of the entire lake *when level,* than has hitherto been afforded. There are, during every season of navigation and more often in winter, many periods of time, from a few days to a week or more, when calm weather prevails from one end of a lake to the other, and only the *information gathered during these periods* and by means of a *uniform system* of observations can be valuable and useful to the hydraulic engineer in the endeavor to find a cause for the present gradual lowering of the lakes, or to determine the probable effect of channel improvements and canal construction upon the level of the lakes and their connecting waterways.

Many eminent engineers have expressed the opinion that the gradual lowering of the lake levels during the last ten years

has been caused by enlargement of the outlet of each lake, viz.: *Lake Erie* by a gradual wearing or breaking away of the rocky crest of Niagara Falls and channel excavations in Niagara River. *Lake St. Clair* by excavations for a twenty-foot channel in Detroit river and across the Grosse Pointe shoal. *Lake Huron* by like channel improvements at the foot of the lake and the St. Clair Flats canal. There are some who believe that whenever or wherever the lakes have been "tapped" by canals and other artificial outlets, the level of these lakes has been lowered, and this includes the Erie canal and the Welland canal as well as both of the hydraulic power canals immediately above Niagara Falls, and—last but not least—must also include the sanitary canal at Chicago, the splendid product of modern engineering skill, by which, as Mr. Cooley says, enough water is to be turned from Lake Michigan to raise the Mississippi *one foot at St. Louis!* (405.)

On the other hand there are optimistic engineers who have faith in secular fluctuations, seven years of high or ascending and seven years of low or descending water levels, and who point with confidence to the extremely high water of 1838 and the low water of 1819 and say: "What has been, may be again;" and while they exult over the fact that their opponents cannot bring forward conclusive proof of the soundness of their theories, they themselves fail to present any evidence in support of the optimistic view.

It has been the writer's privilege to obtain, during the past nineteen years, some knowledge and experience regarding fluctuations of the surface of the lakes, especially Lake Huron, which leads him to believe that the present system of collecting water level records falls short of furnishing the data required by the advocates of a deep waterway. The herein described method of measuring the monthly, annual and secular changes in the height of the water surface in the respective lakes and connecting waterways is therefore submitted and recommended, for the purpose of investigation with a view to adoption, to all engineers who are desirous of making water level observations the basis of a practical, more than theoretical, demonstration of their opinions and calculations.

September 4, 1896.

RAISING THE LEVELS OF THE GREAT LAKES.

BY B. H. MUEHLE, U. S. ASST. ENGINEER,
DETROIT, MICH.

The necessity for a deeper channel between the connecting waters of the lakes to accommodate larger vessels and an increasing commerce had been apparent during several years, when in July, 1892, the so-called 20 and 21-foot ship channel between Chicago, Duluth and Buffalo was projected and, by the aid of liberal government appropriations, dredging operations commenced in the following year. At the same time supplemental projects for connecting this deep waterway with the Atlantic Ocean and the Mississippi river were discussed and developed by civil engineers of national reputation. In furtherance of these projects conventions have been held at different times and places and while the 20 and 21-foot channel became a reality and the so-called sanitary canal at Chicago was being pushed to completion, the efforts in behalf of the canal to the Atlantic culminated in the organization of the International Deep Waterways Association and the appointment of a joint commission of engineers charged with the duty of investigating the subject and reporting to Congress.

The situation as it appears to an outsider, may be described as follows: There are evidently three elements in the Deep Waterways Association which are pulling in opposite directions, while ostensibly working for a grand scheme of great utility and lasting benefit to commerce in general. The Lake Carriers' Association, with its ship channel from Chicago and Duluth to Buffalo, stands in the middle, with the government engineers and money to back it; on one side we see the so-called sanitary canal at Chicago supported by the state of Illinois and an authorized capital of $30,000,000; and on the other side we find the advocates of a deep-water canal around Niagara Falls. With the two latter enterprises tapping the

lakes at both ends and thereby lowering their levels, is it not probable, if not absolutely certain as I believe, that the 20 and 21-foot channel will be seriously affected in a manner not expected nor desired by its friends?

The all-important question whether the construction of deep water canals between the lakes and the sea will affect the lake levels has been answered affirmatively by all the eminent engineers who have given the subject their attention. But there is a great difference of opinion as to the extent, and that difference is caused principally by the insufficiency of available water level records, and incidentally by the desire on the part of engineers to prove either the harmlessness of the canal projects, or their detrimental effect on the levels of the lakes, as the individual interests may direct.

The platform of the I. D. W. Association was admirably written to please everybody, especially the first paragraph, which advocates the construction of "deepest practical channels between the several lakes and lake ports and the seaboard or foreign water without the necessity of transshipment." This may be interpreted to authorize taking water *and commerce* from Lake Michigan via the Mississippi river to the Gulf of Mexico, or the taking of water *and commerce* from Lake Erie to the Atlantic around Niagara Falls, or it may mean to permit enough water to remain in the lakes to fill the deep channels dredged by the U. S. government at an expense of several millions for the special benefit of inter-lake commerce or navigation between principal lake ports.

The difficulty of reconciling these different propositions is increased by the prevailing low stage of water in the lower lakes, the origin of which is still a subject for scientific discussion. If the water levels had an upward tendency it would seem immaterial how much water is taken at either end for legitimate purposes. But the reverse is the fact and the downward movement has been continuous, with the exception of a slight rise during the years 1893 and 1894, ever since the high water of 1886.

The Lake Survey Plane of Reference, the so-called high water of 1838 was but a trifle more than one foot higher than

the water level of Lake Huron as represented by the monthly mean of June, 1886. Between these years, 1838 and 1886, secular fluctuations of the water level have not been as regular as the believers in a seven-year rise and fall would like to demonstrate and may be briefly described as follows: 1847 extremely low, 1852 high, 1855 low, 1859 high, 1866 low, 1871 high, 1872 low, 1876 high, 1879 low, 1884-6 high, none higher than 1876 and 1886, none lower than 1847.

During the months of June, July and August, 1896, the level of Lake Huron had reached the datum plane of Lake Michigan at Chicago, the low water of 1847, as shown on the accompanying hydrographic diagram.

Inasmuch as, in the absence of accurate measurements and sufficient data, it has hitherto been impossible to demonstrate to a certainty what has caused these secular fluctuations of the water levels of the lakes in general and this last downward movement in particular, the suggestion of a new line of thought in the direction of a solution of this question may be appropriate and timely even if it does not convince the reader of the correctness of the conclusions drawn therefrom; but as the damage to the inter-lake commerce would be incalculable if the season of 1897 brings no relief by a rise of the levels, either naturally or artifically, a careful study and comprehensive investigation based upon something better than guesswork, assumption or inadequate or misleading information should be undertaken without delay by those whose interest or duties to the public lie in that direction.

In presenting my views upon this subject I prefer to confine myself to a description of the hydraulic conditions of Lake Huron and the Saginaw river, partly because I have been able to become familiar with these waters during my official connection with government improvements, and principally because I believe that the same or similar conditions prevail at all rivers and harbors on the chain of lakes, so that the result of my observations may be verified by comparison.

Prior to government improvements on the Saginaw river its mouth was obstructed by a bar with but eight feet of water over it during the season of navigation and less in winter; and

in the upper river navigation was difficult on account of the notorious Carrollton bar and other shoals with less than seven feet navigable depth. These obstructions have been removed by the government at different times by dredging channels through them as follows: The outer bar was cut through about 200 feet wide in 1869 to depth of 12 feet, in 1883 *et seq.* to 14 feet and since 1893 to 16 feet. In the upper river, channels have been dredged to give 10 feet navigable depth in 1874 *et seq.* and 12 feet since the year 1883.

The Saginaw river drains an area of about 5,800 square miles, its principal tributaries are the Tittabawassee, Shiawassee, Bad, Flint and Cass rivers. Forty years ago all of these were navigable; small steamers carrying the U. S. mails, passengers and freight, plied between the Saginaw river towns and the cities of Midland, St. Charles, Flushing and others, and even many miles farther up the streams to the lumber camps and early settlers. The high stage of water then prevailing is said to have continued through the greater part of each season of navigation, generally commencing with a so called spring freshet which, however, often rose to the dimensions of a flood. At such times the low lands between the Saginaws and Bay City and the prairies along the Shiawassee, Flint and Bad rivers were covered for miles around. In the city of East Saginaw, 20 miles from the mouth of the Saginaw river, the water used to rise to a height of six to eight feet above low water mark, filling cellars of buildings several streets back from the river and setting the wood paving blocks afloat on Water street.

About 25 to 30 years ago the business of bringing pine logs from the woods along the tributaries to the Saginaw river sawmills in rafts had grown to enormous dimensions, and as the inland cities as well as many lumber camps could then be reached by rail, the regular steamboats were crowded from the upper streams by the more important log interests. At the same time it was noticed that the spring freshets came in smaller volume and did not last so long each succeeding year. Since the high water of 1886 there has not been a spring freshet worthy of the name.

The commonly accepted explanation for these changes has been that on account of the clearing of the pine lands along the watershed of the tributaries the snow melts quicker, the sun has better access to the wet ground, which hastens evaporation, and "we haven't near so much rain now than we used to have," *et cetera*. All of this may be true, but the permanent disappearance of the enormous quantities of water which formerly filled these streams annually cannot be accounted for on these theories alone, and therefore, as the gradual diminution has been coincident with the removal of obstructions in the Saginaw river, especially at its mouth, the conclusion forces itself on the mind of the investigator, that the enlargement of the natural outlets of the river is primarily responsible for the gradual lowering of the water in the Saginaw river and its tributaries.

The keynote which has been sounded by a board of engineer officers of high rank when it declared that "tapping the lakes must reduce their level" is of far-reaching significance when it is applied to all other bodies of water. If "tapping" means making an opening or outlet, it must also in its general application mean enlarging an opening already provided, because when the size of a new opening is equal to the difference between the cross sectional area of an old, and that of an enlarged outlet, the same effect on the level of any given body of water will be produced. If tapping the lakes reduces their levels, and this axiom has not been successfully contradicted, then the periodical enlargement of the outlets of all rivers and streams which feed these lakes must also result in draining their headwaters and tributaries by permitting greater quantities of water to pass on more rapidly and continuously to mingle with the waters of the lakes.

While there are no data at hand from which comparative measurements or quantities can be given, it will be conceded that the additional annual supply of water to Lake Huron from a stream with a water shed of 5,800 square miles, caused by artificial openings made at different times and of different sizes must be of immense proportions. Assuming that rainfall and drought follow each other in the usual way at more

or less irregular intervals, causing a fluctuation in the supply of water to the streams, and allowing for variations in proportion to precipitation, evaporation and barometric influences, the fact still remains, that all the water which discharges into the Saginaw river passes through the enlarged openings made by the government more steadily, continuously and quickly than it did or could prior to these improvements. The result is seen in the dry beds of creeks and small tributaries which formerly held water enough to at least float a log. There is not an inhabitant of the Saginaw Valley, to my knowledge, who ever expects to see a real old-fashioned spring freshet again, and there are many who believe as I do on the subject, even to the extent of the proposition that if at any time the bars and shoals should be permitted to grow to their former dimensions, higher water levels in the Saginaw river and its tributaries would surely result in less than a year.

There is no evidence that the hydraulic changes in the Saginaw river are anomalous or peculiar features of that stream, hence I take it for granted that every river which adds to the body of water of which Lake Huron is the final receptacle, will show upon investigation the same conditions and characteristics before and after improvements have been made, as those above described.

The levels of Lakes Michigan and Huron are generally described as being on the same plane and within the scope of this discussion they may be so considered. Yet there are those who believe that Lake Michigan with a length of about 340 miles must have a perceptible fall toward its only outlet (now at least), the straits of Mackinac, and Lake Huron a length of about 230 miles another trifling slope to its only outlet, the St. Clair river; and when it is considered that a slope of only one inch in 47 miles would make a difference of one foot between the water levels at Chicago and Fort Gratiot respectively, it appears to be within the range of possibility that one or more lines of precise levels across the lower peninsula of Michigan

would demonstrate the fact that Lakes Michigan and Huron are not on the same level.

There can be no doubt, however, as to the effect which an increase or decrease in the supply of water to Lake Michigan must have upon the water level of Lake Huron, therefore both lakes may be considered as one water basin with its outlet at Fort Gratiot. Along the shores of this basin there are at least thirty-six harbors which have been constructed, with the aid of government appropriations, by removing obstructions from the mouths of navigable streams of various sizes similar to those at the Saginaw river above described. The effect of the sum of the large quantities thus added from time to time to the volume of the water in these lakes as the improvements progressed may be traced and recognized in a general way upon the chart of water levels (a brief description of which I have given above); the seasons of high water following those during which government improvements have been carried on. Thus the high water period of 1884-85-86 appears to have been caused by the extensive excavations made immediately prior or during that period.

On the other hand, as a material check upon this gradual rise of the levels of the lakes caused by artificially adding to the supply of water, we find an artificial increase in the volume of *discharge* which has been produced by enlarging the outlets of the lakes in the process of constructing a deep-water channel, in other words, by the same "tapping" process. This work began in 1874, at the Lime Kiln Crossing near the mouth of the Detroit river, where a ledge of rock with only thirteen feet of water over it has been cut through a width of 440 feet and to a depth of 20 feet, thus enlarging the cross sectional area of the river by over 3,000 square feet. The dredging operations were carried on so slowly and with such long intermissions on account of tardy appropriations (the work was not completed until Oct. 1, 1890), that the effect which this tapping might have on the level of Lakes St. Clair and Huron, or even

that of the Detroit river itself, was not taken into consideration, and many engineers even ridiculed the idea that so insignificant an opening or enlargement could or would constitute an important factor in the gradual lowering of the lake levels.

The other deep water-way improvements at the foot of Lake Huron, at St. Clair Flats, at Grosse Pointe and the mouth of the Detroit river, followed in rapid succession and, as a matter of fact, co-incident with the lowering of the levels of Lakes St. Clair and Huron during the last two years (the monthly means of 1895 averaging one foot lower than those of 1894. See diagram.) In the absence of any other reasonable or even plausible explanation based on facts many engineers are now convinced that these excavations at the outlets of the lakes and connecting rivers are mainly responsible for the prevailing low stage of water which affects even the levels in the dredged channels so that the present navigable depths are less than the 20 or 21 feet originally designed. Furthermore, I believe that the reduction of the level of Lake Huron by "tapping" or enlarging the outlets would have been proportionately greater if the extensive improvements at the mouths of the rivers had not been made, the enlargement of their outlets permitting the discharge of greater amounts of water into the lake and thereby partially restoring the quantities withdrawn from the lake.

That the increase in the supply by river improvements has not been equal in recent years, to the increase in the discharge, is evidenced by the present low stage of the water levels.

In order to demonstrate the method by which I sought to arrive at a satisfactory solution of the question at issue, I have prepared two tables, the first of which contains a list of harbors where government improvements have been carried on and which I call the "plus" table because it illustrates a more than plausible explanation of several periods of *increase* in the volume of water in Lakes Huron and Michigan. The second table gives a brief description of all deep channel improve-

ments at the lake outlets, this I may call the "minus" table, because it enumerates all possible causes for *decreasing* the volume of water in these lakes.

The information contained in these tables was obtained from the official reports of the Chief of Engineers of the U. S. army to the Secretary of War, and is, therefore, authentic and reliable.

I. TABLE SHOWING CHANNEL IMPROVEMENTS AT THE MOUTHS OF RIVERS EMPTYING INTO LAKES MICHIGAN AND HURON.

	Names of Rivers.	Original Depths. Feet.	Projects for deepening. Depths. Feet.	Years.	Original estimates.	Appropriations to 1895. From.	Amounts.	Appropriations, 1896.	Total to date.
1	Manistique river	7	12	1880–1	$6,000 00	1880–1	$6,000 00		$6,000 00
2	Cedar river	3	14	1883	138,000 00	1882–4	30,000 00		30,000 00
3	Menominee river	4	14	1871–4	212,000 00	1871	222,062 00		222,062 00
			16	1890	109,609 80	1890	80,580 03	$7,150 00	87,730 03
4	Oconto river	2	8	1882	150,000 00	1881			
			16	1894			74,000 00	4,000 00	78,000 00
5	Pensaukee river	2	10	1883	50,000 00	1882–4	15,000 00	1,000 00	16,000 00
6	Fox river (Green bay)	6	14	1872–4					
			16	1892	226,915 00	1866	347,602 50	25,000 00	372,602 50
7	Ahnapee river	2	12	1884	185,000 00	1871	178,000 00	5,000 00	183,000 00
8	Kewannee river	2	14	1881	200,000 00	1881	125,014 00	25,000 00	150,014 00
9	Twin rivers	2-3	12	1870	265,588 80	1871	209,500 00	5,000 00	214,500 00
10	Manitowoc river	3	12	1852		1852			
			14	1881		1866			
			16	1895	348,182 64	et seq.	356,040 50	44,440 00	400,480 50
11	Sheboygan river	4	12	1852		1852			
			15–16	1873		1864			
			18	1881	195,000 00	et seq.	368,448 91	26,000 00	394,448 91
12	Sauk river	1	10	1869					
			12	1876	184,000 00	1870	189,036 50	5,500 00	194,536 50
13	Milwaukee river	3½	12	1852					
			18	1868	No records.	1836	346,425 36	27,000 00	373,425 36
			19	1895					
14	Root river (Racine)	0 6	12	1843					
			15	1866					
			16	1889	No records.	1844	309,785 00	27,000 00	336,785 00
15	Pike creek (Kenosha)	0-3	12	1852					
			15	1866		1844	275,307 41	24,000 00	299,307 41
16	Chicago river	1-10	16	1888					
			20	1893		1870	1,810,630 18		1,810,630 18
17	Calumet river	6 10	16	1888		1870	762,400 00	75,000 00	837,400 00
18	Trail creek (Michigan City)	0 11	16	1882	131,375 00	1836	421,763 00	80,000 00	501,763 00
19	St. Joseph river	3 7	16	1888–92	519,113 00	1836	469,113 00	30,500 00	499,613 00
20	Black river (South Haven)	6 7	12	1867–92	262,000 00	1867	237,000 00	15,000 00	252,000 00
21	Kalamazoo river	5	12	1867–82	175,699 46	1868	157,439 00	15,000 00	172,439 00
22	Black lake (Holland)	5	12	1866–92	291,615 31	1866	294,615 31	10,000 00	304,615 31
23	Grand river	9	18	1867–92	804,366 15	1866	739,366 15	70,000 00	809,366 15

24	Muskegon lake	7	12	1866-90					
			15	1892	589,000 00	1867	434,000 00	30,000 00	464,000 00
25	White lake	5	12	1866-92	337,550 00	1867	284,550 00	5,000 00	289,550 00
26	Pentwater lake	4	12	1867	327,713 40	1867	243,820 00	5,000 00	248,820 00
27	Pere Marquette lake	7	12	1867					
			18	1890	381,682 00	1867	363,435 00	25,000 00	388,435 00
28	Manistee river	7	12	1866					
			15	1890-92	408,000 00	1867	360,000 00	15,000 00	375,000 00
29	Portage lake	0-5½	15	1879-94	267,500 00	1879	125,500 00	25,000 00	150,500 00
30	Frankfort lake	3-4	12	1866					
			18	1895	325,659 85	1866	333,659 85	15,000 00	348,659 85
31	Pine river (Charlevoix)	2-3	12	1868-84	186,000 00	1876	120,500 00	20,000 00	140,500 00
32	Cheboygan river	6	14	1871					
			15	1880	395,000 00	1871	148,000 00	12,000 00	160,000 00
33	Thunder Bay river, at Alpena	7	13	1876					
			14	1881					
			16	1889	55,851 48	1876	49,000 00	2,500 00	51,500 00
34	Au Sable river	5	10	1766	114,754 40	1867	113,970 00	----------	113,970 00
35	Sebewaing river	3 4	6-7	1873-81	15,000 00	1873	15,000 00		
			8	1895	36,718 11	1896	----------	5,000 00	20,000 00
36	Saginaw river, at mouth	8	12	1867					
			14	1882					
			16	1893					
	Upper river	7	10	1874					
			12	1882	735,795 00	1866	708,750 00	40,000 00	748,750 00
	Totals	----------	----------	----------	----------	----------	$11,325,313 70	$721,090 00	$12,046,403 70

To this list should be added all the harbors along the east coast of Lake Huron, where channel excavations at the mouths of rivers have been made by the Canadian government, notably those at Godrich, increasing the depths of water in Maitland river to 16 feet in 1874-75-76; also at Collingwood and other harbors along the shore of Georgian Bay.

It will be observed that the St. Mary's river is not included in the above table, although it is a feeder to the same lake basin and has been improved by the U. S. government. According to the latest information I have on the subject, a gradual rise of the level of Lake Superior up to about nine inches has been observed ever since the international bridge piers were built at the Soo and other obstructions placed in the river at the rapids. If investigation should develop proof that this demonstration of cause and effect is correct and true, then the St. Mary's river ought to be added to the list contained in the second, or "minus" table.

II. TABLE SHOWING DEEP WATER-WAY IMPROVEMENTS AT THE OUTLETS OF LAKE HURON, ST. CLAIR RIVER, LAKE ST. CLAIR AND DETROIT RIVER.

	Localities.	Original depths. Feet.	Projects for deepening.			Original estimates.	Appropriations to date.	
			Depths. Feet.	Widths.	Years.		From.	Amounts.
						Cub. yards.		
1	Foot of Lake Huron—Sec. 5. Ship channel	16	21	2,400′	1893-96	256,000	1892	$542,192 12
2	St. Clair Flats canal	2-6	11	300′	1855 et seq.	$27,232 00	1866 to 1890	764,810 00
			13	300′	1867-71	351,133 00		
			16	200′	1873	80,000 00		
			18	300′	1886	365,000 00		
						Cub. yards.		Net cost.
	Sec. 6. Ship canal	.....	20	300 to 800′	1893 & 1894	950,000	.....	$107,024 00
3	Grosse Pointe channel—Sec. 7. Ship channel	15	20	800′	1893-96	2,900,000	.....	642,228 97
4	Detroit river:							
	a. Ballard's Reef	16.5	20	800′	1893	$180,000 00	1892	88,742 66
	b. Lime Kiln Crossing	13	20	300′	1874			
			20	440′	1883-6-8	1,374,500 00	1874-90	704,257 34
						Cub. yards.		
5	Bar Point, head of Lake Erie—Sec. 8. Ship channel	16	21	800′	1893-96	1,086,000	.....	106,636 00
	Total	.....	.....	.....	.....	.....	.....	$3,035,891 09

These tables do not give sufficient details in quantities and figures for computations, because much time and space would be required for compilation, but they are intended to be used as an index to the great store of information to be found in the annual reports of the Chief of Engineers and at the same time give a general idea of the value of investigation in this direction. Taking the water level curves published in the report for 1892 as a basis, it is desired, for instance, to find an explanation for the gradual rise of the level between the low stage in 1879 and the high water in 1883, we look up the total amounts of excavation during each of the intervening seasons as indicated in table I and deduct therefrom the sum of excavations during the same period indicated in table II; the difference will be a reliable estimate of the principal cause of such rise, which may, however, be subject to slight modifications by reason of excessive rains or drought if records of these are available.

Following this method of investigation to its extreme limit it will be found that the prospects for a general rise in lake levels in the near future are as remote as a return of spring freshets and high water in the Saginaw Valley, and for similar reasons.

Therefore, artificial means of raising the levels of the lakes should be applied at once in order to not only restore the full depths of water in the 20 and 21 foot channels which have been materially reduced during the last two years, but to provide also sufficient water for additional excavations projected in connection with the proposed enlargements of the Lime Kiln Crossing and the St. Clair Flats Canal.

It being admitted by all prominent hydraulic engineers, that a simple, easy and inexpensive way to permanently raise the water level of a lake is to reduce the cross section of the natural outlet by building a dam, this method should be adopted without any more delay than is involved in the proper presentation to Congress of the urgent necessity of these works, and obtaining a liberal appropriation for commencing and insuring a systematic and energetic prosecution of the project.

While the details of construction will undoubtedly and most properly be entrusted to the government engineers who are charged with the superintendence of all similar works of river and harbor improvements, a general plan may be suggested as follows:

1. A dam at the head of the rapids above Niagara Falls, to be built in shoal water, projecting from the American shore at right angles to the current, by laying two parallel lines of large boulders, the interval filled with concrete; this will contract the water-way so as to back up the water in Niagara river, raise its level and permit the continuation of the deep water channel from Lake Erie to Tonawanda Harbor.

2. A dam built of timber cribs filled with stone, extending from the Canadian shore at or near Fort Erie at the head of Niagara river in the direction of the Horseshoe Reef, for the purpose of contracting the outlet and raising the level of Lake Erie.

3. Similar dams connecting the east shore of Grosse Isle with Hickory island, thence to Sugar island and beyond in the direction of Bar Point, at the mouth of the Detroit river; these may be built of two rows of sheet piling, the space between them filled, and a slope towards Lake Erie formed, by depositing the spoils from future excavations at Lime Kiln Crossing.

4. A dam connecting the Canadian shore with Peach island (Isle aux Pêches) at the head of the Detroit river for the purpose of raising the level of Lake St. Clair.

5. The outflow from St. Clair river should be checked by closing the upper entrances of most of the minor channels composing the delta of St. Clair Flats which are useless for general navigation, leaving, however, small openings for the passage of small sail or row boats used by sportsmen.

6. Finally a spur dam should be built somewhere in the St. Clair river between Port Huron and Stag island for the purpose of checking the strong current caused by a fall of about 16 inches between Fort Gratiot lighthouse and the mouth of Black river.

Much has been said and written about regulating works and adjustable dams similar to those used on the upper Ohio

river and proposed in the Mississippi and other western streams, by means of which large volumes of water are stored or held in reserve during high stages or floods, and utilized in filling the channels when and where needed. In my opinion the hydraulic conditions of these streams are not analogous to those of the northern lakes and their connecting waters. The annual fluctuations of the latter do not exceed an average of 1.5 feet and, when measured only during calm weather, less than one foot; and the higher stage always occurs during the season of navigation, when it is needed, while the lower stage prevails in the winter months. Thus it appears impossible to successfully and practically apply the regulating scheme upon the lakes.

Therefore, the dams built for the purpose of raising the levels of the lakes may be made just as permanent as the excavations were designed to be which caused their reduction. The total cost of this system of dams will be difficult to estimate, as it depends principally on their length, which must be determined by the result of water level observatons during the progress of construction. But to begin with, a minimum of cost may be approximately estimated from the data now available as soon as the details and method of construction shall have been determined upon and developed.

The cost, whatever it may be, will be found insignificant compared with the far-reaching benefit surely to be derived from the scheme. A simultaneous rise of only two feet in every one of the many harbors along the shores of Lakes Erie, St. Clair, Huron and Michigan and of Detroit and St. Clair rivers will be hailed with satisfaction and delight by all the people interested in inter-lake navigation, and would be deemed cheap at any price. When it is considered how tedious a process it has always been to obtain from Congress sufficient appropriatons for an increase of the navigable depth in any one particular harbor for the benefit of a growing commerce, the proposition to accomplish this, on a large scale and in all harbors alike, by simply carrying out a project for restoring and preserving the navigable depths of water in the 20 and 21 foot channels, will commend itself to, and will doubtless secure the favorable consideration of Congress.

Someone has suggested that a legal question is involved when the water levels are raised by human ingenuity instead of the laws of nature. What are now low lands, and probably partly under some kind of cultivation, will be submerged in either case, but while in the last named contingency it would be difficult to find the proper court in which to sue for damages, in the former case the selection of an unbiased jury will be the greatest obstacle; I venture to state that no jury will convict and assess damages against the United States in any of the lake cities and towns, unless it has been specially imported for that purpose from the interior of the state, far removed from the beneficial influences of improved harbor facilities.

Aside from the necessity of raising the levels artificially for the purpose of restoring depths of water in the dredged channels of all the harbors along the lakes it is apparent that provision must also be made for future improvements involving additional changes in supply and discharge. There are two artificial outlets of the Niagara river, one a surface canal furnishing power to manufacturing establishments below the falls and the other the great tunnel of the Niagara Falls Power Company, which already furnishes electricity to the city of Buffaloand whose desire to extend the scope of their enterprise is only equalled by the unlimited quantity of water which they can intercept on its way from the higher to the lower level of the falls. The right of this company to divert the water of Niagara river in any large quantity for private purposes and profit has been questioned by the courts, but I have no knowledge of the present status of the case.

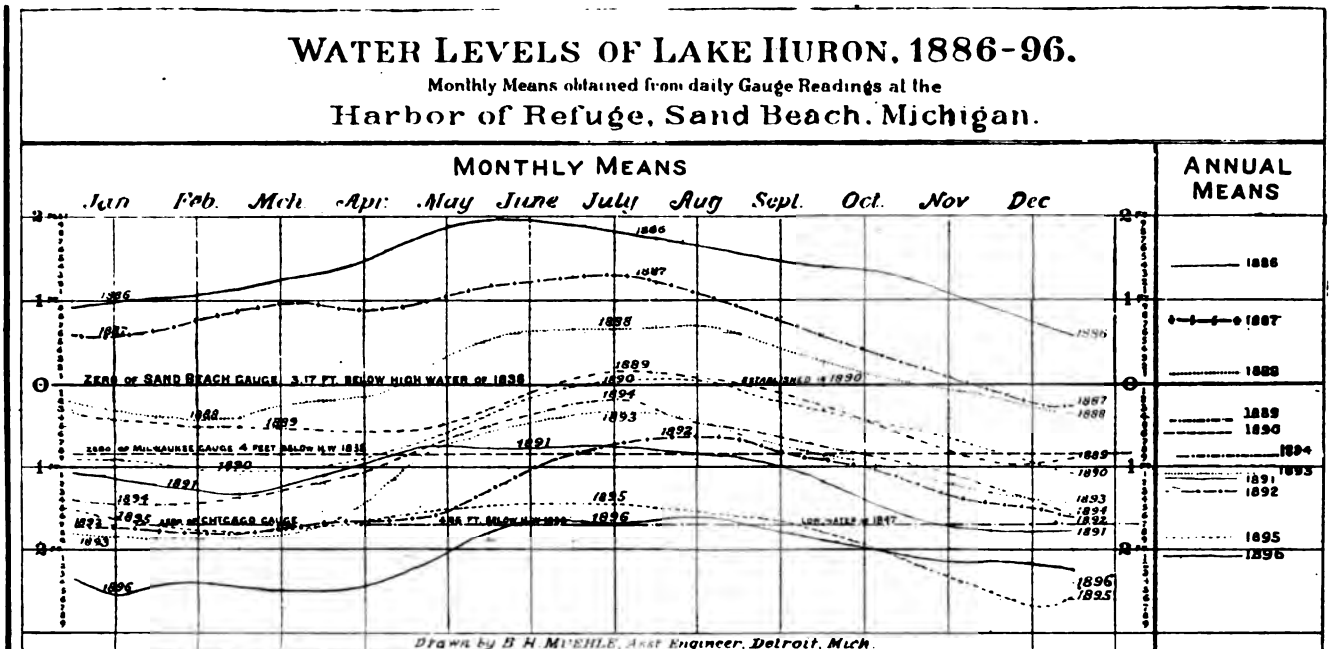
The construction of the Welland Canal and its enlargement in more recent years have undoubtedly caused a small reduction in the level of Lake Erie, and in a greater measure such a result will follow the construction of a deep water canal around Niagara Falls to Lake Ontario. But inasmuch as the discharge through canal locks is not continuous, but intermittent, depending entirely on the frequency of lockages, the additional outflow from Lake Erie on account of these canals can be measured, regulated and controlled.

In this respect the so called sanitary canal at Chicago is not designed to meet the favor of the friends of deep water-way between Chicago, Duluth and Buffalo, for the following reasons: This canal taps the great lake basin at its head; it is not intended to merely act as a main sewer for the city of Chicago, but to float vessels to the Mississippi "without the necessity of transshipment"; it does not require locks for vessel passages and none are proposed, as they might and would seriously interfere with the uninterrupted current needed for its sanitary purposes; it will turn the flow of the Chicago river in the opposite direction, in fact that river is to be taken out of my "plus" table and put into the "minus" table with all the detrimental effects which such change implies. The cross-sectional area of the new outlet will be only one-sixth the size of the only other outlet of this lake basin, at the narrowest part of the head of the St. Clair river, below Fort Gratiot.

The effect of the continuous discharge of 10,000 cubic feet per second (the maximum amount permitted under the State law), reducing the level of Lake Michigan is variously estimated: by the canal engineers at 0.2 and 0.4 feet, by the U. S. engineers at 6 inches, by others still lower; there is just as much uncertainty now, as to what damage will be done to the vessel interests of the lakes by the sanitary canal as there has been hitherto in regard to the effect of the excavations for the 20 and 21 foot channels.

As soon as the conclusion shall have been reached that the present low stage of water has been caused by "tapping" the lakes, and that nothing less than a system of plugging them up again by damming their outlets will cause the water levels to rise, all the engineers representing the various opposing interests above described should join hands in inaugurating an artificial plan for restoring the levels, and, until the necessary appropriations shall have been obtained, plans and methods determined and construction actually commenced, not a single drop of water should be permitted to enter the sanitary canal at Chicago.

January 1, 1897.


WATER LEVELS OF LAKE HURON, 1886-96.
Monthly Means obtained from daily Gauge Readings at the
Harbor of Refuge, Sand Beach, Michigan.
MONTHLY MEANS
Jan Feb. Mch Apr. May June July Aug Sept. Oct. Nov Dec
ANNUAL MEANS
ZERO OF SAND BEACH GAUGE, 3.17 FT. BELOW HIGH WATER OF 1838
ZERO OF MILWAUKEE GAUGE 4 FEET BELOW L.W. 1918
1886
1887
1888
1889
1890
1894
1893
1892
1891
1895
1896
Drawn by B. H. MIEHLE, Asst Engineer, Detroit, Mich.

HYDROGRAPHIC SURVEYING.

EDWARD BARRINGTON.

It is advisable, as a preparatory prerequisite, for the chief of party to supply himself with one or more representations of the locality to be surveyed, upon a scale previously determined, showing the shore line, if surveyed, the positions of all triangulation points falling within their limits, and of any objects or features, topographical or artificial—such as buildings, lighthouses, etc., which have been fixed by the plane table or otherwise, and which may be useful in the execution of the hydrography. There should also be secured a description and sketch—if procurable—of each triangulation point, showing how it is marked, and the bearings and distances of any objects near at hand, by which it can be located.

It sometimes happens, the hydrography precedes the topography, in which case the shore lines must be sketched in from best procurable data, in pencil, and careful angles taken at various points, and plotted on the sheet. Generally speaking the shore lines are obtained from the office, or from the topographer, and entered on the sounding sheets. In special cases, where hydrography is made previous to securing the shore line, signals may be erected and used, the location of which is determined subsequently by the topographical party; but, should the latter be not on hand approximate positions of the signals is determined by the hydrographic party, and shore line sketched in. The working scale of sounding sheets is usually $\frac{1}{10000}$ where the lengths of lines permit its use. The off shore work may be protracted on a scale of $\frac{1}{20000}$ or $\frac{1}{40000}$. Special surveys are frequently required on a scale of $\frac{1}{5000}$.

Now determine carefully the general scheme for the direction of the sounding lines. Lines should be run on ranges when possible, and soundings taken at regular intervals, the

recorder indicating the time by the order "sound" to the leadsman. The length of interval will be regulated by the depth of water, and when changed, position angles must be taken. The frequency of the casts to be made depends upon the greater or less irregularity, or slope of the bottom. The best test of the sufficiency of data supplied by a hydrographic survey is to ascertain if the curves can be drawn for all depths, without leaving doubt as to their directions anywhere. For navigation purposes, it is generally sufficient to trace these curves for every fathom up to three fathoms; the determinations to the farther depth of five fathoms aiming to be good to fractions—say tenths—of a foot. Beyond this depth greater latitude is allowable; fractions of a fathom, or half fathom, or even whole fathoms, in deep water work, taking the place of fractions of a foot. In particular cases where the figure of the bottom is very irregular, it may be desirable to draw half-fathom curves, or even curves, to every foot of depth, within the limits stated.

To secure uniformity in the reduction of soundings, preparatory to plotting them, the following rules should be followed:—

Enter in the sounding book, the reduction for tide, to the nearest tenth of a foot.

Take sufficiently accurate soundings, depending upon the depth of water, to enable them to be reduced as follows, viz.:—

Deep sea soundings—To nearest fathoms.

Outside 15 fathom curves—To nearest half fathom.

Between 15 and 10 fathom curves—To nearest foot.

Between 10 and 4 fathom curves—To nearest half foot.

Between 24 and 12 fathom curves—To nearest quarter foot.

Inside 12 foot curve—To nearest tenth foot.

Whenever soundings on a line indicate shoals or reefs, the spot must be revisited and thoroughly developed. Soundings showing even less than average depth must be regarded as indicating a possible shoal, much more so when two or more such shoaler soundings are on contiguous lines, the space between them should be carefully sounded by traverses, going far enough each way to cross the lines already run, keeping in mind the irregular outlines often assumed by shoals.

On a field of work exposed to the sea, reefs and shoals may be discovered, located, or verified during heavy weather by occupying two or more stations, and with an instrument cutting in the breakers. The depths can be ascertained during fair weather.

When the survey of a shoal or rock is finished, care must be taken to note upon the spot all ranges, bearings, and marks which lead over it, or close to it, on every side. Lines of soundings should be run on all ranges used for marking channels.

A pole should be used instead of the line when sounding in shoal water—10 feet or less; and when the bottom is muddy, a disk may be placed on the lower end of the pole to prevent it from sinking into the surface of the bottom. The line and pole must be conveniently marked to meet the conditions of accuracy already noted, which should not be less than .015 of the depth sounded.

More space is covered with fewer lines, when they are parallel. Lines should be crossed at right angles. If there are long stretches of shoal water near the shore line, the square work can be connected with the shore line by zig-zags, in a light draught boat, the work being closed or opened according to its importance, by decreasing or increasing the angles between the lines.

Great care must be taken when building signals over stations, not to disturb the objects used as marks, and in no case should the center be moved in the slightest degree; this does not apply to a surface mark over a sub-surface center. Should it be necessary to remove any marks, reference them with four stakes, placed so as to not interfere with the required work. Surface marks are sometimes of a perishable material, and they should be replaced with great care when necessary.

Having established signals, and set up the tide-gauge, the lines of soundings can be begun. Exercise judgment in laying out the work with reference to the anchorage of the vessel, and in shifting the anchorage to suit the work, so as to give the least distances to pass over in going to and returning from work, to save time, save coal if steaming and the strength of the men if pulling.

Having determined where the line is to begin, with reference to the state of tide, wind, sea, etc., the boat or vessel is placed at that point. The observers, recorders, leadsmen, etc., take their places; the chief directs the recorder what note to make for fixing the beginning of the line. The beginning of a line should be fixed by angles, but, when the signals are not observable or visible for the purpose, additional notes must be made and the angles taken as soon as practicable.

Triangulation points are indicated by a point surrounded by a black circle, inclosed in a red triangle, thus ◬ ; all other points are indicated by dots inclosed in circles, thus ⊙ , using red ink for topographical, and blue ink for hydrographical, points.

Before selecting stations for erecting signals, a reconnaissance should be made. When points are chosen, search for the exact locations of those first needed, and, if recovered, erect signals over them. Shifting shore lines, traveling sand dunes, the operations or maliciousness of men, etc., occasionally remove station marks; it is rarely, however, that some of the points cannot be recovered, and any two that are intervisible can be used as the extremities of a base for redetermining stations. A signal, or object used as such, will be fixed with sufficient accuracy for hydrographic purposes by obtaining lines of direction—commonly called "cuts"—passing through it from two or more already established points. The cuts should intersect upon the required point at an angle of not less than 30 degrees nor more than 150 degrees.

Ordinary poles make good signals, when lines are not too long. Flags should show contrast of colors, as black and white, red and white, red and green, or entirely white, or of one bright color. The best signal in a boat or vessel, is blue, white and red, in horizontal stripes, or black in place of blue. The flag should be square, and slashed with a knife to make it useless for other purposes. When the lines are long, tripods built around the signal poles afford good marks; the sides of the pyramids facing the observer are covered with rough boards, a foot apart, from near the apex, half way or more to the

System a

ground. They should be whitewashed if showing against woods or black ground, and blackwashed if showing against the sky or light ground. To save lumber and transportation, small signals can be built with driftwood, small trees or saplings, and barrel staves for boarding up. Contiguous signals should be dissimilar, in order not to mistake one for the other. When seen by reflection, the danger of mistaking signals is much increased. Natural or artificial objects will, if conveniently located, serve excellently as signals; and if any are observed in close proximity, they should be cut in and plotted. Float-signals can be made with oil or beef barrels, which are visible one or two miles. For outside work, on shoals which are exposed at certain stages of the tide or wind to breakers, condemned car wheels, with long slender poles and flags might be utilized. A tripod made of gas pipes is excellent for very exposed places.

When locating a signal, by occupying its center, observe a full round of angles, ,and repeat the observations frequently.

Usually, the triangulation work precedes the hydrography, and the latter use the same signals as the former. When the reverse is the case, the tripods for sounding are erected independent of the triangulation signals, not touching it in any part, and the slats so arranged as to allow a view of the cone, the upper third and base of the pole, if a signal with a pole in the ground, or if a tripod signal, to allow a view of the crotch of the tripod and of all above it. As the wind often causes these tripods to lean, a sufficient interval should be left between them and the signal to prevent their touching in such a case. The axis of the sounding signal should be the same as that of the triangulation signal. A signal erected exactly upon a triangulation point or other previously fixed point, should bear the name already given to that point. If near but not exactly upon the point, either give a new name to the signal or the old name with "No. 2," or the date, as "Spar No. 2," or "Spar '78."

Enter all angles taken for fixed siguals in the angle book. These books are arranged for recording both the angles observed for locating signals, and those taken from stations

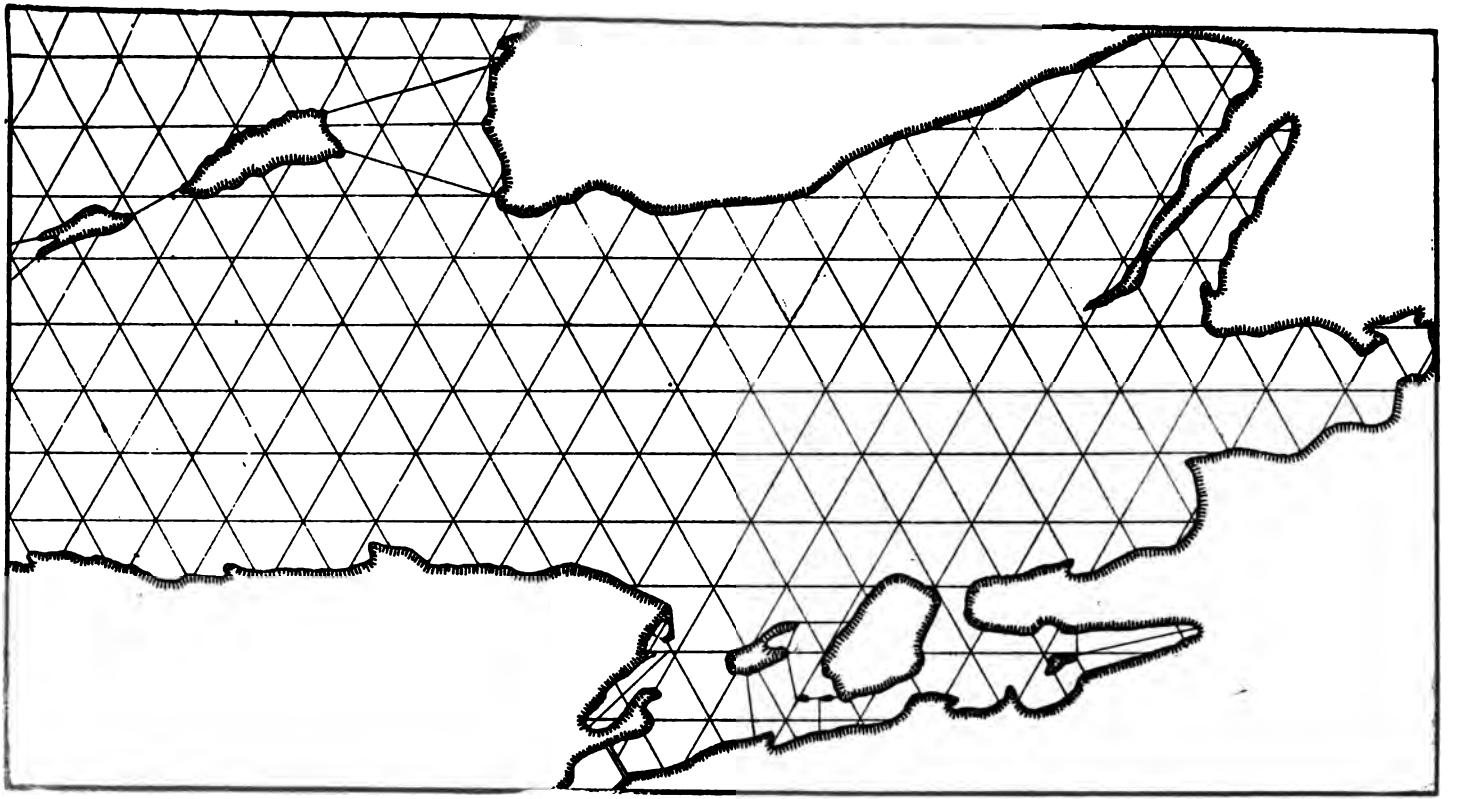
System b.

on shore for fixing, from time to time, the position of a vessel or boat when sounding. In working along the coast, in deep water of harbors, or where the currents are strong, it may be convenient to place two observers at shore stations, to cut upon the vessel, while for verification, the angle at the vessel is also observed. The signals for observation are generally given from the vessel by dropping a flag. Along the coast, the signal at the mast head of the vessel is often easily distinguished when the shore stations cannot be seen from a convenient place of observation on the vessel. In certain cases, the cuts should be made at stated times; the watches of the observers and the vessel being frequently compared, and their rates allowed for. The records of angles will be entered in both angle books while the soundings are noted, as usual, in the sounding book; the complete record thus requiring three note books. Theodolites are generally employed for this class of work, though sextants may be used if necessary. Though not absolutely necessary, it is preferable that the stations of the two observers be intervisible. Each will take the angle between the station selected and the vessel or boat. When a sextant is used, the name of the right-hand, or reflected, object will always be named first in noting the "Object observed." Theodolites are graduated from left to right, from 0 to 360 degrees; consequently, if using a theodolite to measure the angle between two points, the left-hand object must be first named. A time ball, or flag, will be shown from the vessel each time a position is required, and angles observed when it is dropped. Each observer and the recorder on board the vessel will carefully note the time as well as the number of the position. Relative to the choice of signals: for position, prefer near signals; and for direction of current, the most distant. Hydrographic notes for charts should be prepared and carefully reviewed by the chief of the party, and should it be necessary to complete the records on sheet before transmittal to office, add the following: Plot soundings, and draw curves to show 6, 12 and 18 feet depths; approximating, where slope is rapid and no soundings have been taken. The 6-foot curve should be in green, the 12-foot in red, and the 18-foot curve in blue. Note

the character of the bottom carefully and frequently, especially on bars, where changes are often rapid. A mere notice of hard or soft bottom is not sufficient. The height above the plane of reference of shoals bare at low water must be given. Every page of each note book should be as complete and clear as possible in information, so that no referring back will be necessary. Sometimes it happens that a new signal has to be established in running lines of soundings; in such cases the angles observed may be entered, with notes giving their object and the name of the new signal, in the sounding book, but they should be transferred to an angle book upon returning to the vessel.

The marine chart indicates to the navigator the depths of water, hidden dangers to be avoided, and reveals the general characteristics in the configuration of the bottom, which may enable him by casts of the lead, to recognize his position, or the course he is making. The hydrographer should, therefore, so shape his work that the exact positions and magnitudes of the dangers may be made to appear, as well as the undulations of the bottom. He should especially examine rocks, sunken wrecks, or other abrupt obstructions, and develop alluvial shoals. There are several systems for running lines of soundings, shown in the plates given herewith, each to be used in accordance with the character and the minuteness of the work required. The most simple is a set of lines normal to a coast, direction of a stream, or line of shoal, at such distances apart as the locality may require; another system cuts the field into rectangles; a third system consists of double lines, running each at an angle of 60 degrees to the line of coast or 30 degrees to the general direction of the river, bay, etc., making angles of 60 degrees or 120 degrees with each other, with another system, parallel with the coast, or normal to the direction of the river, bay, etc., crossing the first system of lines at their intersection, so that each of the angles at the point of intersection would be equal to 60 degrees. This system gives the best results with the fewest lines. An examination of the plates will give some idea of the other systems.

Judgment must be exercised in selecting the best system to

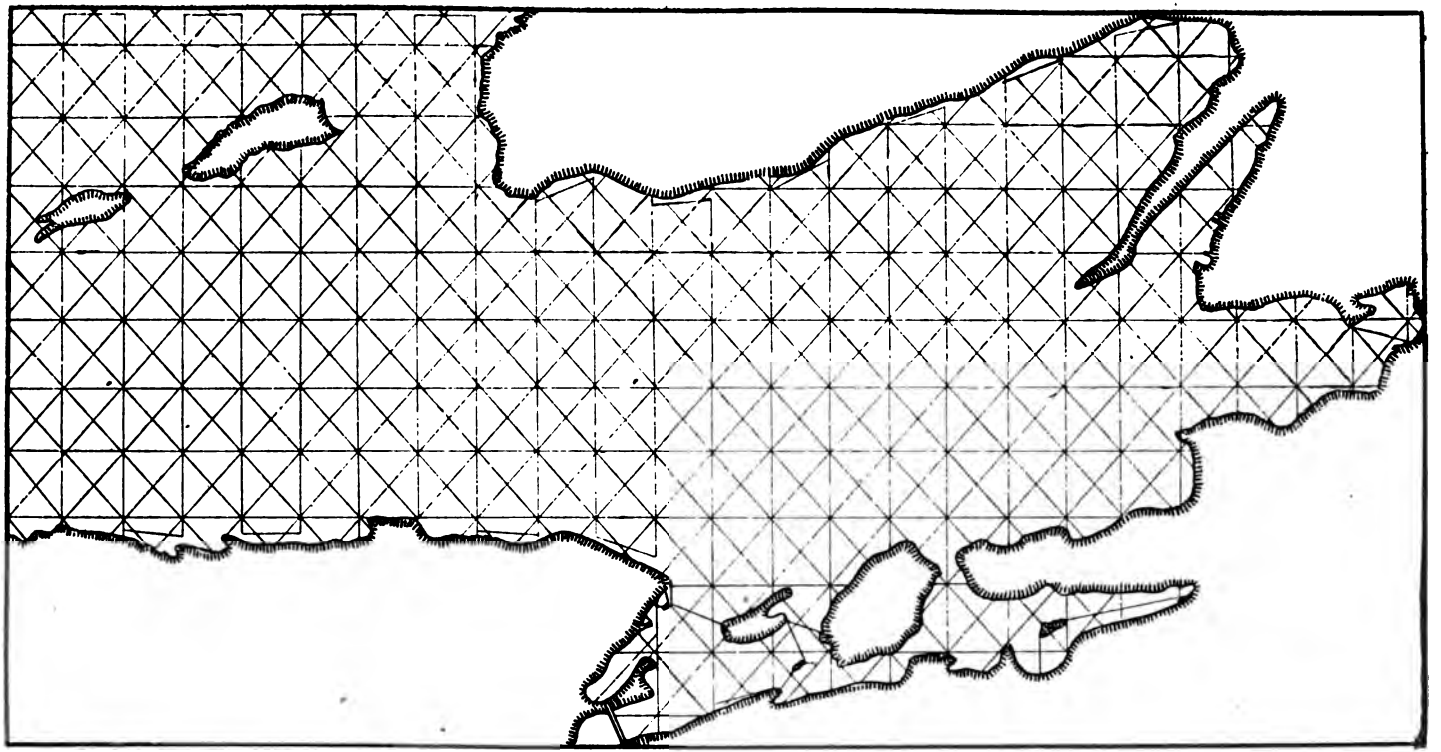


System c.

use at any given point, and the distances of the lines apart, so as to incude all important developments, the best system always being the one which offers the most check lines. Where costly improvements are to be made, soundings can be determined upon almost each square foot. No one general system is sufficient to develop every irregularity of bottom. In making a reconnaissance or rough survey of an important waterway, traversing may be resorted to, in order to save time; but, even in this case, the alternate courses should be normal to the stream in order to furnish cross sections. The lines should be at least eight to the mile, crossed at right angles by a similar series, if the scale used is 10,000,—and on a scale of 20,000, five lines to a mile are sufficient. In some instances, thirty to the mile are necessary for special development.

When shoals or slopes are run by traverses, crossing the curves of equal depths nearly at right angles, these lines should be intersected by others in the general direction of these curves. A small error in position on the steep slopes gives a large error in the depth. Shoals and flats bare at low water should be sounded over, at or near high water, and the heights above the plane of reference given, just as are the depths below that plane. These heights will be plotted as minus soundings, or with the minus sign before each.

Of the three methods, commonly used for locating lines of soundings, that by located ranges is the readiest, especially in boats for short lines, where angles may be done away with. By the use of a watch, and sounding by intervals of time, great accuracy may be obtained. The observations of angles, from the boat or vessel, upon three signals—the "three-point problem"—is perhaps the most useful method for general purposes. Sextants are largely used for hydrographic work, but theodolites, graduated to half-minutes, are found useful in measuring angles from shore tripods or lighthouses. In using the non-repeating instrument it should be set up with the zero to the left of any position the boat is likely to take; otherwise necessary computations for the recorded reading of the vernier will be required. To avoid errors, the instruments must be kept in



System d.

good order. *Observers should not permit the instruments in the hands of their attendants.*

Great care must be taken to make all records as full and complete as possible, in every detail; in order that the draftsman may have no trouble in plotting same. At the beginning of each day's work, enter in the sounding book the time the party left the vessel and the distance to the field; the fact that the sextants, clock, and lead lines have been examined and found correct; the names of the observers, recorder and leadsmen, and should any changes be made during the day, a note to that effect in the column of remarks at the time it occurs. If there are two observers, state which takes the right and which the left angle. At the close of the day's work, note again the condition of the sextants, clock, and lead lines, and their errors, if any; the time of returning to the vessel, and the distance from the working ground. At the head of each page give, first, the locality; second, the name of the vessel or boat employed; third, the year, month, day of month, and letter of the day in its proper color. In the time column, note kind of time—local or standard of meridian—and opposite each note of position, including those of the beginnings and ends of lines, the hours, minutes and seconds as shown by watch or clock; in the same column, whether sounding at regular or irregular intervals, the clock time in minutes and seconds, of each cast must be recorded. The column for soundings has two sub-heads: "Fathoms and feet," and "Feet and tenths." If the soundings are being recorded in fathoms and feet, a line should be drawn through the words "feet and tenths," and vice versa. The columns headed "reduction for tide" and "reduced soundings," respectively, are filled out subsequently. Note the character of the bottom at the head of each new page, and at each change reported by the leadsman, making the entry opposite that of the sounding at which the change was observed, in the column headed "angles and ranges" are to be recorded all angles and ranges taken from time to time to locate the vessel or boat, together with the names of the objects observed upon, the entry to be made in each case opposite that of the sounding

taken at the same time, and a check, with index number corresponding to number of angle, made opposite the sounding itself; or if the angle or range is taken between two soundings, place the check just above the second.

State in column of remarks, where line begins; the course steered in running the line; any change of course at time it occurs; force and direction of the wind; state of the sea, rough or smooth; force and direction of the current, if any; bearing and estimated distance of any object passed by the boat, which is plotted on the chart; end of line, and all information which will facilitate or check the plotting of the work. In recording always omit one line after the sounding on which a position was taken, and from four to six lines between the end of one line of soundings and the beginning of the next. Make erasures only when absolutely certain of momentary errors. Remarks as to correctness of soundings must never be erased, but may be crossed out and subsequent remarks added in explanation.

The more notes taken the better. Observing recorders supply many themselves, always carefully checking with reference mark the sounding to which note refers. Irregular soundings should be at once reported, and marked with a star, when satisfied of its correctness. Observers should not confuse the recorder by giving second angle before the first is recorded; the right angle should always be given first. Positions, whether by angles, ranges or merely by time, are numbered in one series for each day's work; the number being enclosed in a symbol like that for square root, $\sqrt{109}$. Record angles by writing, first, the names of the right hand and middle objects, and the angular distance between them, then the name of the left hand object and the angle between it and the middle object, thus:

$\sqrt{109}$ Spar to Barrow.
27° 13′
Top.
53° 18′

System e.

System f.

The word "to" should be used and not "and" between the names, as the right-hand object is reflected to the left-hand object. Ranges are indicated by writing upon the same line the name of the two objects in transit, and to the right of them three zeros with a line drawn through them, thus:

$\overset{98}{\diagdown\!\!\!/}$ Spar and Stub, ⊖-⊖-⊖

Which means that spar, stub, and the vessel or boat are at the moment in the same straight line. An angle and range taken simultaneously give the best determination of position—with the possible exception of intersecting ranges. The entry should show whether an object on the right was reflected to the objects in range, or whether the objects in range were reflected to one to the left, thus:

$\overset{110}{\diagdown\!\!\!/}$ Spar to Barrow and Top, ⊖-⊖-⊖

29° 15′ or

$\overset{111}{\diagdown\!\!\!/}$ Spar and Stub, ⊖-⊖-⊖ to Top,

34° 48′

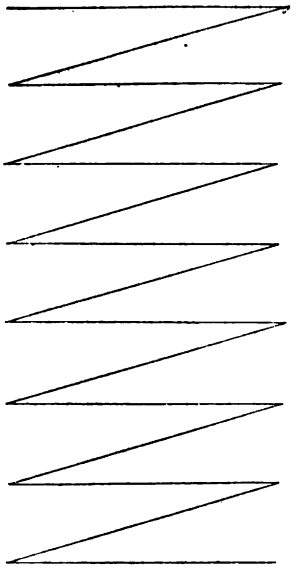
The names of the objects observed upon should be written out for each position, when even the same objects are used for consecutive positions. Never write "ditto" or "same" instead of repeating the names of signals. Never interchange sounding books used by the vessel and each boat. Each boat requires two books, so that one may go out while the other is in the hands of the draftsman.

The boats should be steered on ranges, where practicable. When surveying harbors or rivers, if the banks are bare, use flags for ranges. The soundings should be taken at fixed intervals of time, to insure accuracy, as well as a matter of convenience, these intervals varying with the depth of water. When depths change rapidly, this may not be possible; in such case the time of each cast should be recorded. Usually more soundings are taken than can be plotted on the sheets, which permits the selection of characteristic soundings; and they are convenient should it be necessary to replot the work on a

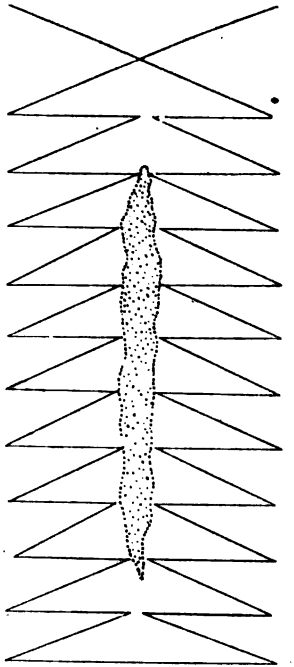
larger scale. Whenever it is decided to change the interval, angles should be taken, so that the interval may be uniform between each two determined positions. If running by time on a range, note the time in its proper column, and place opposite to it the number of its position in its symbol. Angles for position should be observed often enough to insure the line's preserving its direction, and also whenever any marked change of depth occurs. Determine the position by angles, when a change of course occurs. For determining a position by the "three-point problem," carefully select the three objects. The case commonly called a "revolver" or "swing" is when the three objects and the observer are on, or nearly on, the circumference of the same circle, in which case the position of the observer cannot be plotted accurately from the angles. Small angles are to be avoided, and large angles are not always well conditioned. A favorable position is where the observer is near the center of the circle whose circumference passes through the three points. If possible, select three points, of which the center one is nearest the observer, and the points nearly in a straight line.

Record the state and direction of the wind, current, and sea; noting carefully the time of passing from sheltered to exposed positions and the reverse, or from a current to an eddy, or into still water, and vice versa. Note the crossing of tide rips, and give their trend. Squalls and lulls should be noted, if the speed, steering, or drifting of the boat is affected by them. Also note position of whirlpools carefully. When, owing to surf or other dangers, a line cannot be run to the shore, note exactly why it was prevented.

Note exact character of the bottom, and select specimens of same, so that the formations along the coast may be traced, etc. When the bottom is rocky, or when detached rocks are known or expected to exist, the precautions in sounding should be increased. Secure information from every available source, relative to rocks or shoals supposed to exist. Compare charts and publications with the development of the field work. Rocks and shoals should be visited at extreme low



System h.



System g.

water. In harbors, lines should be run alongside quays and wharves; a boat pulling with oars just clear of the sides will give about the distance that the keels of ordinary vessels will occupy. Use a sufficient number of buoys, in determining high points and surface of reefs, the lines running radially therefrom. The development of channels and of bars is of the utmost importance, more especially when the depths of the former are less than 30 feet in the fairway, and if the latter is obstructed. Determine the least water by going over the whole bar with a sounding pole.

Note breakers on the bar, giving their extent, with what winds they occur, at what stages of the tide they make and cease and how nearly, and from what direction they may be approached.

Take great care in selecting lead lines, and soak and stretch them repeatedly. Verify them at the beginning and end of each day's work, at least. Sash cords make excellent lines, the marks being sewn on. This line, when once stretched, rarely changes. Keep the lines in tubs of water. The line should be marked with small white cord for every foot, up to five fathoms, the half fathom mark being distinguished by a cord with a knot, and this designation for half fathoms should continue to ten fathoms. The usual fathom marks are as follows:

1 fathom—A piece of leather with one strip.
2 fathoms—A piece of leather with two strips.
3 fathoms—A piece of leather with three strips.
4 fathoms—A piece of leather with four strips.
5 fathoms—White rag, leather with one strip.
6 fathoms—A piece of leather with one strip.
7 fathoms—Red rag.
8 fathoms—A piece of leather with three strips.
9 fathoms—A piece of leather with four strips.
10 fathoms—A piece of leather with a hole in it.
11 fathoms—A piece of leather with one strip.
12 fathoms—A piece of leather with one strip.
13 fathoms—Blue rag.
14 fathoms—A piece of leather with four strips.

15 fathoms—White rag.
16 fathoms—A piece of leather with one strip.
17 fathoms—Red rag.
18 fathoms—A piece of leather with three strips.
19 fathoms—A piece of leather with four strips.
20 fathoms—Two knots.

The deep-sea line is marked the same as above up to 20 fathoms, and at

25 fathoms—One knot.
30 fathoms—Three knots.
35 fathoms—One knot.
40 fathoms—Four knots.

And so on to 95 fathoms.

100 fathoms—A piece of bunting.
105 fathoms—One knot, etc., etc.

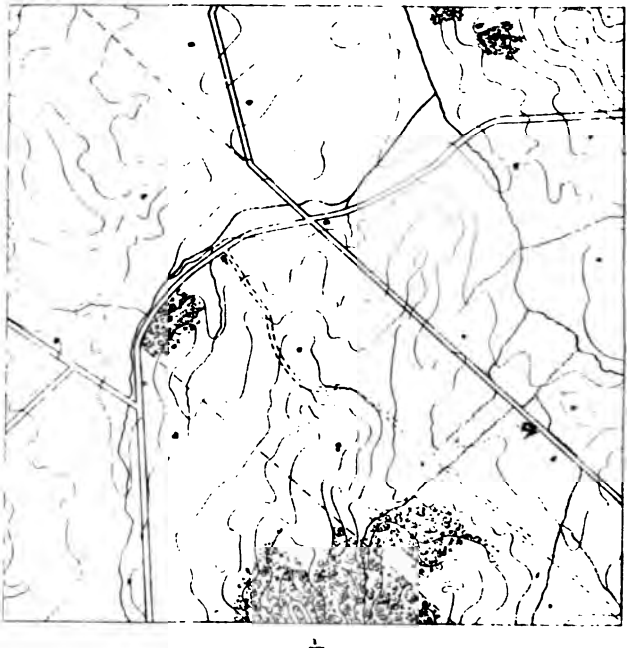
The chief of party will decide when soundings are to be executed from vessel or boats or both, and the number of boats to be worked.

Examine charts carefully in all localities, and obtain all possible information from masters of vessels and local water-men.

Be sure to carefully note all remarkable objects on shore which may be useful as landmarks. Notes upon the finished sheets must give the history of the work, showing the time when executed, and by whom, and the vessel employed. The records of all observations, and the results obtained, must be so complete that they may be used by any one acquainted with the subject. In deep-sea soundings, the record of the navigation should be made as complete as possible, everything being noted—such as currents, drift of the vessel while sounding, error of the deck clock, etc. Plot soundings before sending them to the office. The reductions of soundings, required for the height of the tide, are entered in the sounding books. They should be computed by two persons, or the chief may revise the work of the assistant. Soundings should always be made at the current stations, and recorded at each slack water, together with comments upon the kind of bottom, whether good holding ground, etc., etc.

Reductions on different Scales

Contour interval 20 ft



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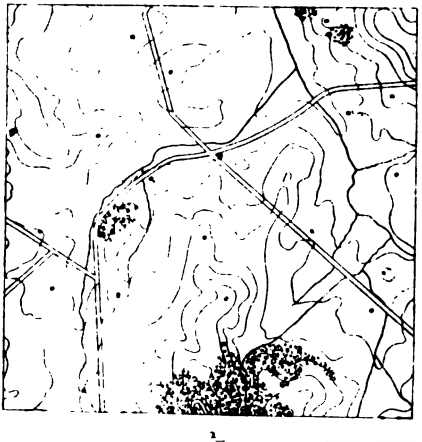

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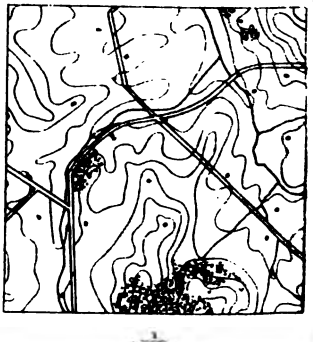

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In all work where the sextant is used, the index correction must be taken frequently, and the record so kept that the correction will be applied to the proper angle.

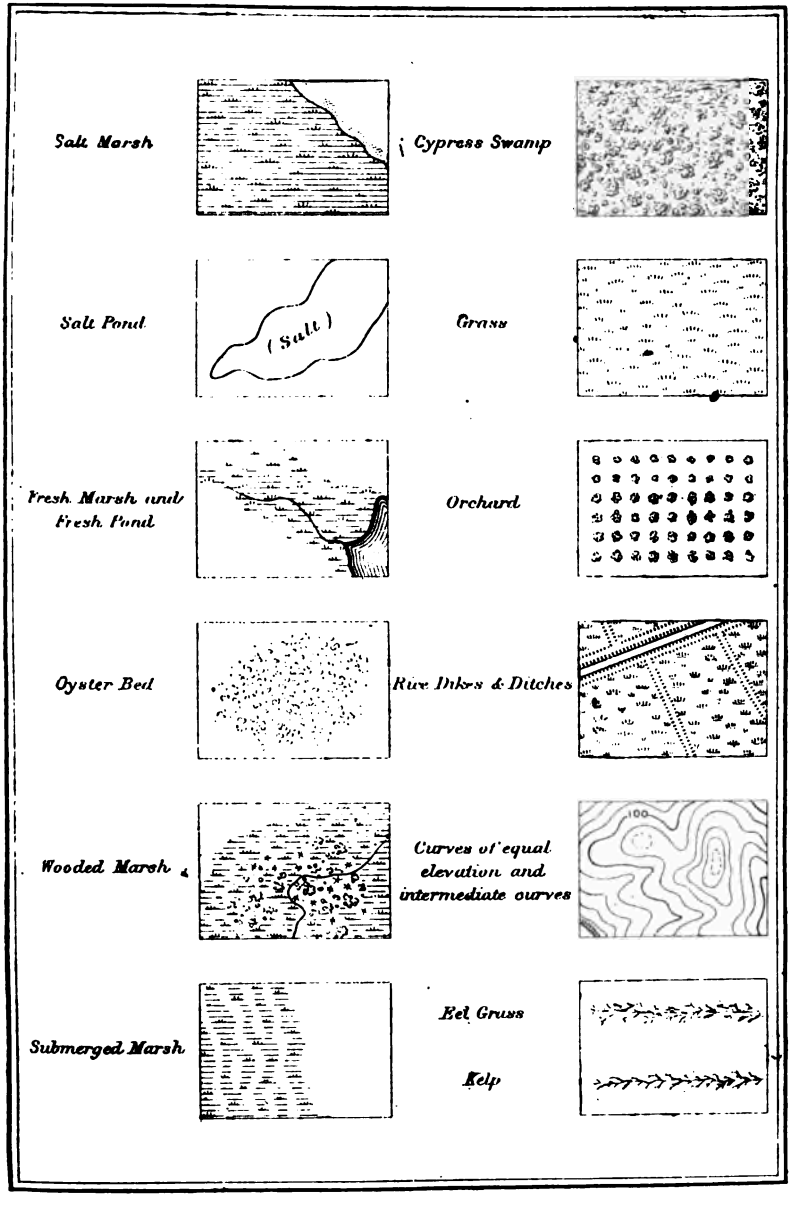
The word "tide" is used exclusively for the vertical movement of the sea or lakes; and "tidal current" is the horizontal motion or movement of the same. The words "rise" and "fall" are used in referring to the tide, and the words "flood" and "ebb" in referring to the tidal current. The word "stand" should be used specifically for the period of time, at high or low water, when no vertical change can be detected; and the word "slack" for the period of time when no horizontal motion can be detected. "Set" and "drift" are terms applicable only to the tidal current—the first for direction and the second for velocity. The "range of the tide" is the height from low water to high water; this term is usually applied to the average height; but upon the charts the expression "mean rise and fall" replaces it. The "plane of reference" is the datum plane to which the soundings upon a chart are reduced, and this datum plane has been fixed as mean low water. By "mean low water" is understood the mean of all the low waters observed, on the Gulf and Atlantic coasts; but, upon the Pacific coast, where there is a great difference between the heights of the two low waters of each day, the plane of reference is the mean of all the lower low waters. In hydrographic surveying, the immediate object of observing tides is to determine the plane of reference, and furnish the means for reducing the soundings to this plane. The tides, however, are observed also for the object of supplying the data necessary to construct a tidal table for the chart. Continuous tidal observations are necessary while the soundings are being made, and in order that the plane of reference may be determined closely and the elements of a tolerable tide table procured, the observations of consecutive high and low waters should be carried at least through an entire lunar month; or, if it be impracticable to observe tides at night, the day tides of two lunar months may be substituted. In selecting a tidal station, reference should be made to the facility for locating the observer. It is generally desirable at a permanent station, where there is no self registering

gauge, that observations be made hourly, day and night, and every ten minutes for half an hour before and after high and low waters, so as to determine the duration of stand. For a reconnaissance, a few days' observation will suffice, noting the time of the moon at which they were made.

Before beginning soundings, a "bench mark" must be established, so in case of accident the gauge may be reset. These bench marks are ascertained by leveling up from the tide gauges.

The simplest and best "tide gauge," in perfectly sheltered localities, is a staff graduated upward in feet and tenths, and so placed that its zero shall lie below the lowest tides. "Box gauges" are used where there is considerable swell, or where the staff gauge cannot be used owing to the great range of the tides. One of the objections to the use of the box gauge has arisen from the carelessness of hydrographers in not properly referring its zero reading to the bench mark. To make this reference properly, a line of levels must be run from the bench to the reading point, and then the distance measured from the zero—or some other stated division of the staff—to the water line of the float, so that the elevation of the bench above the surface of the water, for any reading of the gauge, can be computed. Parties at work on hydrography, outside the coast line, at a considerable distance from the permanent tide gauge have used a "pressure gauge" for reference with success. The gauge must be placed in a situation visited by the same form of tide as that which occurs at the place where soundings are to be made, as the tidal observations are to be used to correct the soundings. The limit of distance at which a gauge may be placed so as to require no correction of the observations for difference of time of tide, may be ascertained by the following general rules: "The rate at which the tide travels is equal to the velocity acquired by a body falling through space from a height equal to half the depth of water." When in the course of a survey it becomes necessary to make new tidal stations from point to point, the different gauges and their benches should be referred to each other, if it is deemed necessary to reduce all the soundings to the same plane. Wherever it becomes

Conventional Signs and Symbols.



necessary to run lines by leveling instruments, round the borders of harbors and bays, the following is a simple and safer method, especially for connecting tidal stations: Make observations upon the two gauges to be referred, every fifteen minutes from one low water to the second following (for the same tides) where there is no considerable river outflow; the average in each case will be "mean level," and the difference between the readings of mean level on the two gauges is the difference in the elevation of their zeros. This rule will not apply where there is considerable river outflow; but the following rule holds good wherever the outflow of river water does not wholly reverse the flood current: Set up graduated staffs at such distances apart that the slacks of the tidal currents shall extend from one to another. By simultaneous observations ascertain the difference in the readings of these gauges at the slack between ebb and flood currents, and again the difference at the slack, between flood and ebb; the difference on the elevations of the zeros of the gauges is equal to one-half the sum of the differences of their readings at the two slack waters.

There are frequently remarkable facts in reference to the tides known to persons navigating the waters in the vicinity of the work. These should be carefully investigated. The highest and lowest tide ever known in the vicinity, its fate and circumstances, etc.

In connection with permanent stations, observations of the direction and force of the wind, barometer, thermometer, and weather generally, should be made; the thermometer being placed on the north side of some permanent structure, if possible, and screened from direct and reflected light and heat. The instrument should be observed before or after taking the observations of high and low water.

The average "luni-tidal interval" commonly known as the "corrected establishment," is the average of the luni-tidal intervals for one or more lunar months. It expresses the average time of high water—the middle of the stand—after the moon's meridian passage, whether it is the upper transit—superior or southing—or the lower transit—inferior or northing. The duration of rise or fall is counted from the middle

time of one stand to the middle time of the next. There should be obtained the data for the highest and lowest tides known to have occurred, provided these can be determined, so as to be referred to the plane of reference and bench. Where such data have been available and recorded they are invaluable in connection with marine construction, drainage, etc.

To properly study tides, the observations must be plotted on profile paper and the curve traced. This affords the readiest and surest means for obtaining a correct plane of reference and noting irregularities, which by this means can generally be traced to some unusual cause. The best hydrographers always plot the curves, and then can study the work intelligently.

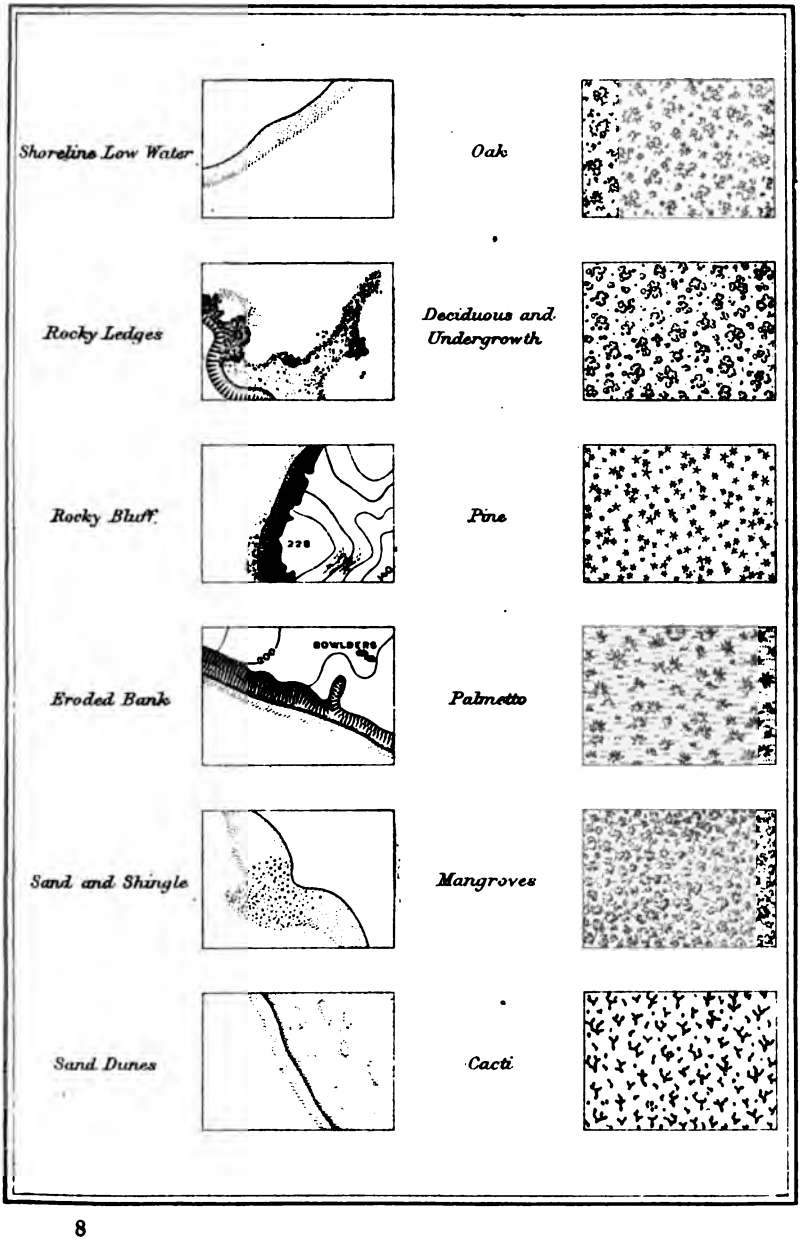
Tidal currents are strictly local, in many respects being affected in much greater degree by the configuration of the bottom, form of section, etc., than the tide. When it is essential or advantageous to know the set or drift, current observations must be made, should dangers or difficulties present themselves. In the channel ways over outer bars, and at the entrances to all inlets, bays or harbors, the currents must be observed. A table should be constructed, showing the times when the ebb and flood currents commence, and observations should be made with that object in view. The times of slack water are, of course, subject to the inequalities which appear in the times of high and low tides, and they are also affected by winds and river outflows to a much greater degree than the tides so that they by no means recur at the same interval after the tide from day to day. The maximum velocity is the least variable element in tidal currents, and is nearly always free from the diurnal inequality, and but little affected by steady winds and river outflows. To compute this element, let the velocity of the ebb or flood current be observed every fifteen or twenty minutes, from one slack water to the next; plot these observations upon profile paper, and draw a line from the apex of the curve so as to bisect all the chords and the base of the figure. The average time to which this axial line corresponds is the middle time of the current, and is found, in long series, to represent the time of maximum velocity. The middle time from

a short series is corrected, so as to represent the mean by a comparison with the times of the tide. The interval of middle time of such series is simply half the sum of the mean intervals of high and low tides. The best times for making current observations are between spring and neap tides, because the times of slack water are subject to variations dependent upon the range of the tide. The effect of prevailing winds should be studied.

Plot current stations as a small circle, from which two arrows should extend, indicating, respectively, the directions of ebb and flood at the time of maximum; and at the end of each arrow this maximum velocity should be stated in knots or nautical miles per hour. Full arrows show direction of flood; half arrows, that of ebb; the dots indicate by their order the direction in which the current turns, and the velocity is written at the head of the arrow.

Current meters are used for observing the currents, or with the ordinary log chip and line or weighted pole and line. The advantage in using the weighted pole instead of the log chip lies in the greater hold it has upon the water in proportion to its exposure to winds, surface ripples, etc. In ports where many chips are at anchor, the surface currents are cut up into bands of unequal motion, and these sources of error in the observations with the chip are in a great measure eliminated in using the pole. Use poles about the ordinary draft of vessels visiting the port. The pole should swim with the upper end about one foot above the surface. Light cod line has been found to give excellent results. The log line should be so divided that, running off from the reel during a period of thirty seconds, they should measure the drift in nautical miles and tenths per hour. The larger divisions—miles—should be marked by leather strips, in which holes are perforated to represent the number. These strips should be placed 50.67 feet apart when the line is thoroughly wet, making no allowances for lee way or drag, between each pair of leather strips, nine knotted cords should be placed at intervals of 5.07 feet, to mark tenths of a mile; the number of knots on each cord indicating the number of tenths. For determining directions of

Conventional Signs and Symbols.



currents at night, special floats have been devised. There should be at least 60 feet of stray line between the log chip or pole, and the initial division or zero, in order that the float may pass beyond the eddies of the vessel before the count begins. The set or direction is determined by measuring the angle subtended between the float at its most distant point and some known object on shore, or by compass, if no shore signals are in sight. The position of the boat, if determinable by angles or shore signals, should be recorded at the strength of the flood, and again at the strength of the ebb. Stop-watches should be compared with the chronometer before used, and the error of the second hand recorded, so that proper allowance may be made, and no subsequent correction of recorded velocities become necessary. Every hydrographic vessel should be provided with a patent log, for registering the speed, and with instruments of the best quality for determining the latitude and longitude.

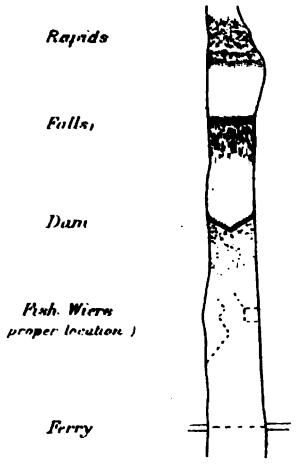
Careful notes of the appearance of the land should be taken, and report desirable views for illustrating sailing directions for entering or leaving harbors, or sailing along the coast in the tracks generally followed. If convenient, these views should be sketched during hydrographic operations. General facts of interest to navigators should be carefuly noted and verified. Note the limits of tide rips and breakers, the effects of change of winds and tides upon them, facts relating to them and the causes of their peculiarities. Obtain correctly the names, and if possible, the orthography of the names of points, headlands, and all bodies of water, shoals, reefs, etc.

Give special attention to the various sources of error in the use of the compass; see that the needle or card is properly balanced and traverses freely, and that the lubber line is correctly placed. The compass should be elevated above the deck as much as possible, so as to be least exposed to the disturbing action of the ship's iron. If deviation is small, mechanical correction is not advised. Before leaving port, ascertain errors by observation; when any change of importance has taken place in the distribution of the iron in the ship, and upon a

great change of latitude. To ascertain the deviation of the compass on different courses, the ship must be swung and the bearings of a distant object taken, with the ship's head on at least the eight principal compass points. The method of reciprocal bearings may also be used. The observations may be laid down to form a napier diagram, as the readiest means of passing from the disturbed to the correct magnetic course, and vice versa. The results should be tabulated for each point of the compass, with the addition of the corresponding headings of the steering compass. The "heeling error" may be tested when the ship is heading north or south. Of course, when at sea, the deviation of the compass may be determined by astronomical observations or bearings, the variation for the place being taken from the chart. Upon leaving port, if the vessel is steady, this is decidedly the best way to obtain the compass error. The variation of the needle from the true north is ascertained on shore in a locality free from local attraction. The latitude, approximate longitude, and local time—or sun's altitude—being known, the variation is readily found from bearings of the sun when near the horizon, taken with an azimuth compass. Accurate determinations of the magnetic declination, however, require the use of a portable declinometer. Observations of this class are usually made by shore parties, and are not required of hydrographic parties except by special directions.

The finished hydrographic sheet must be kept up with the progress of the soundings. The tidal observations connected with soundings must be reduced as soon as the plane of reference is established. Approximate reductions may be made sooner, if necessary, for the purpose of rough plotting. The angles or positions must be protracted upon the working sheet, the same day on which they are taken or determined, and at the same time, if possible, to show the actual positions of the lines. These angles must be plotted on the finished sheet as convenient, thus affording a check on the work. A sufficient number of soundings may be plotted on the sounding sheet in pencil, to show the crossings and the contour of the bottom, so that the requirement of a further examination of any local-

Conventional Signs and Symbols.



Topographical and Hydrographical Stations .....

Triangulation Point .....

Dwelling House .....

Barn .....

Shed and Pen .....

Ruins .....

Windmill .....

Church .....

Cemetery .....

Fence .....

Public Road .....

Road fenced on one side .....

Telegraph Road .....

ity may be determined at once. Determine a sufficient number of points from the observed angles to keep the run of the work of soundings, so as to direct the lines to the greatest advantage.

The most convenient mode of plotting the "three-point problem," where a three-arm protractor can not advantageously be used, is by laying off the angles on transparent paper, drawing the lines from a point suitably chosen upon the sheet, and moving the transparent paper over the drawing sheet until the lines pass through the three points, between which the angles have been observed. The curves for observations of the currents should be plotted, in order to learn whether the results are satisfactory and data complete. Every original hydrographic sheet should contain the following information:

Projection in India ink, with the latitudes and longitudes on each end of each parallel and meridian where they have been determined; and when not, the fact must be stated in a note.

Triangulation, plane table, and such other points as may have been determined or established by the hydrographic party, must be given, each with its distinctive sign. Use red ink for topographic, and blue ink for hydrographic, position of signals.

The shore line must be drawn on the sheet in a continuous black line if it has been surveyed by a topographical party; if sketched in by a hydrographic party, it is to be indicated by a broken line.

The lines of soundings must be in pencil, with the positions, letters, and numbers in ink. When the sheets have been checked, the inking can be completed.

Rocks, reefs, coral and shell banks, sunken or awash, must be marked with the proper signs; if awash at half-tide or high water, the fact must be stated.

The positions of all buoys, light vessels, etc., must be given with their proper signs, and a note must state the condition of tide, the weather, and when determined, with the length of moorings of the light vessel.

The limits of grass, kelp, etc., must be indicated. If the bot-

tom is grassy, it is to be so written. Kelp must be marked with its proper sign.

The names of all islands, points, rocks, reefs, shoals, banks, channels, creeks, etc., must be given on the sheet.

All ranges, bearings for dangers, etc., sailing lines on courses or ranges should be shown as follows:—The range in black lines, broken with long dashes; the bearings in black dotted lines; and the sailing lines in black lines broken with short dashes, with the positions of the objects for ranges and bearings determined, marked and named, and the names of the objects and the purpose of the range or bearing written along its line.

Current stations and tidal stations must be plotted in position.

There should be a reference table, showing:—Date of sounding; letter of reference to date; number of the sounding book; number of angles taken in the day; number of soundings taken in the day; name of vessel or boat.

The following designations will be used for abbreviation of bottoms:—

MATERIALS IN CAPITALS.	COLORS OR SHADES, TWO SMALL LETTERS.	OTHER QUALITIES, THREE SMALL LETTERS.
M. for mud.	bk. for black.	hrd. for hard.
S. for sand.	wh. for white.	sft. for soft.
G. for gravel.	rd. for red.	fne. for fine.
SH. for shells.	yl. for yellow.	crs. for coarse.
P. for pebbles.	gy. for gray.	brk. for broken.
SP. for specks.	bu. for blue.	lrg. for large.
C. for clay.	dk. for dark.	sml. for small.
ST. for stones.	lt. for light.	rky. for rocky.
R. for rock.	gn. for green.	stk. for sticky.
CO. for coral.	br. for brown.	stf. for stiff.
MRL. for marl.		str. for streaked.
O. for ooze.		
K. for kelp.		
WD. for weed.		
GRS. for grass.		

It may not be generally known to all engineers and surveyors, that the "lake survey" use the foot and its decimals; the "coast survey" use the meter; and the "public land survey" employs the Gunter's chain and links, in making their

Conventional Signs and Symbols.

Railroad (each track)

Railroad (large Scale)

Road not fenced

Path or Trail

Stone Wall

Hedge

Embankment

Canal and Lock

Known Altitude 420 ft.

Approx " (approx) 420 ft.

Lighthouse

Light-ship

Lighthouse (small scale chart)

Lighted Beacon, Stake or Post Light

Old Light Tower

Beacon (day beacon, unlighted)

Spindle, Stake or Pile

No bottom at 20 fathoms 20

Kelp

Rock awash

Sunken Rock +

Life Saving Station

Wreck

Anchorage

Buoys (write C. N. or S. for can, nun or spar and Whistle or Bell for whistling or bell buoy)

Red (name color if green, yellow or white)

Black

Horizontal Stripes

Perpendicular Stripes

Lighted

Mooring

measurements. The absurdity of dividing up the government surveys among different independent departments, each of which appears to be wholly oblivious of the standards and methods of the others, must be apparent to every one. It means a needless duplication of work and a waste of effort and public money resulting in disconnected and practically useless or unavailable maps. It is entirely out of accord with popular demands and with modern ideas of scientific work. To continue in the present iniquitous practice is to only increase the cost and trouble, at some future day, of undoing the mischief already done.

A TABLE OF TRIANGULAR AREAS FOR USE IN EARTHWORK COMPUTATIONS.

F. C. SHENEHON.

In the canalization of St. Mary's river—the outlet of Lake Superior—the United States government has done as much earth work as would build a railroad from Chicago to New York.

The methods employed in the determination of quantities of excavation are exceedingly simple and facile, both as regards surveys and computations.

The channel for the most part is three hundred feet wide on the bottom, with such side slopes as the nature of the material will warrant.

Stakes, or slender piles, located by transit intersections, are driven at intervals of five hundred feet on each side of the channel, and two hundred and fifty feet from its axis.

Cork lines are then stretched lengthwise of the channel, on each side from stake No. 1 to stake No. 2. Along this line, egg-shaped wooden floats, or corks, are beaded, and wedged at intervals of fifty feet. These stakes locate the sections that are multiples of ten; the corks locate the intermediate ones.

Spanning the channel between section stakes or corks a tag line is next stretched. This line has narrow ribbons of red, white and blue flannel woven in at intervals of ten feet. The extreme tags of white flannel are five hundred feet apart.

After soundings have been taken at each tag on section zero, the line is moved to Sec. 1 and soundings are taken back across the line.

Soundings have thus been located ten feet apart on sections fifty feet apart.

In bed rock, or boulder formations, cross-sections are taken twenty or even ten feet apart, while soundings across the section are still taken ten feet apart.

The detail of sounding is somewhat varied in these cases.

The conception at the bottom of most earthwork computations is that the solid to be excavated is made up of a train of prismoids; and the sum of the volumes of each of these prismoids equals total volume. The peculiarity of the method here spoken of is that the prismoids are all of the same length.

Just as vertical planes passing through the sections cut the great solid into small pieces, each of which may be readily computed; so vertical lines passing through the sounding points cut the many sided polygon, which is the cross-sectional area, into simple plane figures, triangles and trapezoids.

The three possible varieties of these plane figures are shown on Plate 2.

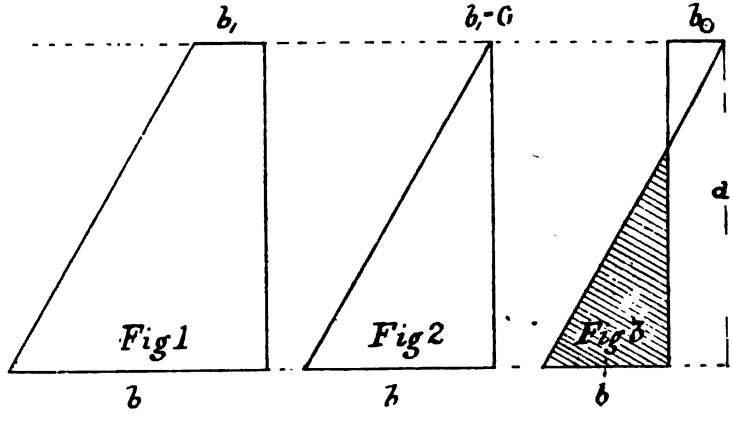


Fig. 1 is a trapezoid; and Fig. 2, a triangle, may be conceived as a trapezoid one of whose bases is zero.

The total area of any chain of these trapezoids is found as follows:—Take one-half of the end bases, add to them all the intermediate bases; multiply this sum by the common height ten. Adjoining trapezoids have common bases.

The triangle shown in hachures in Fig. 3 differs from that of Fig 2 in that its height is less than ten feet, since the two lines do not intersect on the ordinate.

It is vertex to vertex with another similar triangle, called

here the *opposite* triangle whose base b_0 is in the adjoining ordinate.

The area of the triangle whose base is b may be found from the formula—

$$\text{Area} = \frac{db^2}{2(b+b_0)}$$

In which d is the interval between ordinates.

Since in the case under discussion the interval is ten the formula becomes

$$\text{Area} = \frac{5b^2}{b+b_0}$$

Triangles of this form occur so frequently, that in a single final estimate on a short section of rock cutting over two thousand were encountered.

To facilitate in this regard, computation of cross-sectional areas, the table of triangular areas here presented—Plate 1—was prepared.

It gives the areas of triangles with bases from one-tenth of a foot to four feet—advancing by tenths—with the same range in the bases of the opposite triangle.

An example will show the use of the table.

Required area of triangle whose base, b, is 2.3 and the base, b_0 of the opposite triangle is 1.4.

In extreme right or left hand column find 2.3; follow over horizontally until vertically under, or over, 1.4 in the top or bottom lines, the area 7.15 is found. When b is 1.3 and b_0 is 3.4, area is 1.80. When b is 2.8 and b_0 is 0.9, area is 10.59.

Since in practice triangles of greater height of base than four feet are not very numerous; and moreover since those of greater bases may be solved by its use, it was not considered advisable to increase the size of the table by greater inclusion.

When the base of the required or the opposite triangle is greater than four feet, conceive the triangle as made up of two or more smaller ones by dividing the bases b and b_0 proportionally. When b is 7.0 and b_0 is 4.8 area is 20.76, which is gotten by halving 7.0 and 4.8 and taking from the table the

area b=35 b_0=24 or 10.38 and doubling it. When b is 7.7 and b_0 is 6.3 the area is 21.17, because when b is 3.8 and b_0 is 3.2 the area is 10.31 and when b is 3.9 and b_0 is 3.1 the area is 10.86 and the sum of these two is the triangular area required.

If either base exceeds eight and is not more than twelve divide b and b_0 into three parts as nearly as may be equal, and sum up the three triangular areas.

When the cross-sectional areas have all been computed the total volume of excavations in cubic feet may be found by the familiar method. To one-half the end areas add all the intermediate areas and multiply this sum by the distance between sections.

Adjoining prismoids have common bases.

While for simplicity's sake this method of earthwork survey has been spoken of as applied to submarine work, it is not so limited. Its simplicity and uniformity commend it for irregular and extended earthwork of many kinds, borrow-pits, grading of grounds, excavations for large buildings, dyke construction, railroad terminals or yards, and street work.

Table of Triangular Areas.

F.C. Shenehon

Base of Required Triangle	Base of	.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	
0.1		.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1
0.2		.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.2
0.3		.14	0.14	0.13	0.13	0.12	0.12	0.12	0.12	0.11	0.11	0.11	0.10	0.3
0.4		.24	0.23	0.23	0.22	0.22	0.21	0.21	0.20	0.20	0.19	0.19	0.18	0.4
0.5		.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.30	0.29	0.28	0.28	0.5
0.6		.51	0.50	0.49	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.6
0.7		.68	0.66	0.64	0.63	0.61	0.60	0.58	0.57	0.56	0.54	0.53	0.52	0.7
0.8		.86	0.84	0.82	0.80	0.78	0.76	0.74	0.73	0.71	0.70	0.68	0.67	0.8
0.9		1.07	1.04	1.01	0.99	0.96	0.94	0.92	0.90	0.88	0.86	0.84	0.83	0.9
1.0		1.28	1.25	1.22	1.19	1.16	1.13	1.11	1.09	1.06	1.04	1.02	1.00	1.0
1.1		1.51	1.47	1.44	1.41	1.38	1.34	1.32	1.29	1.26	1.23	1.21	1.19	1.1
1.2		1.75	1.71	1.67	1.64	1.60	1.57	1.53	1.50	1.47	1.44	1.41	1.38	1.2
1.3		2.02	1.97	1.92	1.88	1.84	1.80	1.76	1.73	1.69	1.66	1.62	1.59	1.3
1.4		2.28	2.23	2.18	2.13	2.08	2.04	2.00	1.96	1.92	1.88	1.84	1.81	1.4
1.5		2.56	2.50	2.45	2.39	2.34	2.29	2.25	2.21	2.16	2.12	2.08	2.05	1.5
1.6		2.84	2.78	2.72	2.67	2.61	2.56	2.51	2.46	2.41	2.37	2.33	2.29	1.6
1.7		3.14	3.07	3.01	2.95	2.89	2.83	2.78	2.73	2.68	2.63	2.58	2.53	1.7
1.8		3.45	3.38	3.31	3.24	3.18	3.11	3.05	3.00	2.95	2.90	2.84	2.79	1.8
1.9		3.76	3.68	3.61	3.54	3.47	3.41	3.34	3.28	3.22	3.17	3.11	3.06	1.9
2.0		4.08	4.00	3.92	3.85	3.77	3.70	3.64	3.57	3.51	3.45	3.39	3.33	2.0
2.1		4.41	4.32	4.24	4.16	4.08	4.01	3.94	3.87	3.80	3.73	3.67	3.61	2.1
2.2		4.74	4.65	4.56	4.48	4.40	4.32	4.24	4.17	4.10	4.03	3.97	3.90	2.2
2.3		5.09	4.99	4.90	4.81	4.72	4.64	4.56	4.48	4.41	4.34	4.27	4.20	2.3
2.4		5.43	5.33	5.23	5.14	5.05	4.97	4.88	4.80	4.72	4.65	4.57	4.50	2.4
2.5		5.79	5.68	5.58	5.48	5.39	5.30	5.21	5.12	5.04	4.96	4.88	4.80	2.5
2.6		6.15	6.04	5.93	5.83	5.73	5.63	5.54	5.45	5.36	5.28	5.20	5.12	2.6
2.7		6.51	6.39	6.28	6.17	6.07	5.97	5.88	5.79	5.70	5.61	5.52	5.44	2.7
2.8		6.88	6.76	6.64	6.53	6.42	6.32	6.22	6.13	6.03	5.94	5.85	5.76	2.8
2.9		7.25	7.13	7.01	6.89	6.78	6.67	6.57	6.47	6.37	6.27	6.18	6.09	2.9
3.0		7.64	7.50	7.38	7.26	7.14	7.03	6.92	6.82	6.72	6.62	6.52	6.43	3.0
3.1		8.03	7.88	7.75	7.63	7.51	7.39	7.28	7.17	7.07	6.96	6.87	6.77	3.1
3.2		8.42	8.26	8.13	8.00	7.88	7.76	7.64	7.53	7.42	7.31	7.21	7.11	3.2
3.3		8.82	8.64	8.51	8.38	8.25	8.13	8.01	7.89	7.78	7.67	7.56	7.46	3.3
3.4		9.23	9.03	8.89	8.76	8.63	8.50	8.37	8.25	8.14	8.03	7.92	7.81	3.4
3.5		9.64	9.42	9.28	9.14	9.01	8.88	8.75	8.63	8.51	8.39	8.28	8.17	3.5
3.6		10.06	9.82	9.67	9.53	9.39	9.26	9.13	9.00	8.88	8.76	8.64	8.53	3.6
3.7		10.48	10.22	10.07	9.92	9.78	9.64	9.51	9.38	9.25	9.13	9.01	8.89	3.7
3.8		10.91	10.62	10.46	10.31	10.17	10.03	9.89	9.76	9.63	9.50	9.38	9.26	3.8
3.9		11.34	11.02	10.86	10.71	10.56	10.42	10.28	10.14	10.01	9.88	9.75	9.63	3.9
4.0		11.78	11.43	11.27	11.11	10.96	10.81	10.67	10.53	10.39	10.26	10.13	10.00	4.0
			3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	

Plate I

DRAINAGE OF LAKE ANGELINE.

JAS. E. JOPLING, M. E.

In the year 1892 the drainage of Lake Angeline was accomplished by the mining companies that own deposits of ore extending under the water.

The bed of what was formerly the lake is situated on the Marquette iron range, and lies within the limits of the city of Ishpeming. The lake was a mile long by about 1,800 feet at its widest and covered 154 acres according to the government survey, though by filling with waste rock and in the construction of railway tracts, etc., and also by cleaning out the stream which forms the outlet the acreage in 1891 had been reduced to 112 acres. Its position among the green stone hills which form such prominent features of the district gave the lake an irregular shape as will be seen by the maps which accompany this article. Its maximum depth was 41 feet, the mean depth being about 20 feet, and from soundings taken in 1891 through the ice, it was estimated to contain 800 million gallons. Its surface was 1,430 feet above sea level or 830 above that of Lake Superior, which is about fifteen miles distant and into which it drains by way of the Carp river. The distance from the lake to the Carp river is a little over a mile and the fall in that length was something over 30 feet, most of which occurred in the last quarter of the mile. The watershed between Lake Superior and Lake Michigan lies only a few hundred feet south of the lake.

The drainage area of the lake is not large, being some 560 acres in extent, including the lake itself, so that except in spring and at the time of heavy rains, little water runs into the basin. The Marquette signal office reports 32 and 1-3 inches of water as the total average precipitation per annum for the past 20 years, of which 23 inches is in the form of rain, and assuming the rainfall here to be about the same, and after

deducting 15% for evaporation principally for the snow, this would give a quantity of water over the drainage area equal to half the capacity of the lake. Most of this area is covered with hard green stone rock so that there are no springs to speak of, while the water has an unobstructed flow from the steep hills from which the original forest has been cleared with the exception of a few ridges.

The iron ore formation lies in basin-shaped deposits at the foot of these hills, and most of these deposits lie beneath the level of the lake. The ore found in them is generally soft and not only irregular in shape, making it hard to find, but it is also covered by a considerable depth of glacial sand and gravel, rendering explorations expensive. Some of the first mining in the district was in the deposits of hard ore lying but half a mile north of the lake, and the map of the original government survey in 1848 records a road from Marquette to settlements at what are now the Cleveland and Lake Superior hard ore mines. Though mining was carried on steadily by the companies operating these mines it was not for several years that the soft ores of the district received attention.

The Pittsburg & Lake Angeline Iron Company was the first to commence operations on the shore of the lake in 1864, but it was not until the winter of 1886-7, when the Cleveland Iron Mining Company made the discovery of a body of ore extending beneath the water, that the formation under the lake was known to be of any value. The ore of the Cleveland Company was found with the aid of a diamond-pointed drill, the holes being put through the mud and sand into the ore beneath. The Lake Superior and the Pittsburg & Lake Angeline companies soon afterwards began work under the bed of the lake and development by all these companies went on for a few years though it was merely a question of time until the drainage of the lake would become necessary.

In 1891 the problem was thoroughly discussed and various schemes were suggested to get rid of the water. The opinion of several engineers was asked and bids on the different plans were received. The more important of the plans were:—

1. To pump out the lake after lowering the outlet as much as possible.

2. To use a pipe as a syphon taking advantage of the fall which occurs in three-quarters of a mile beyond the outlet. This would only take off 28 feet and it would be difficult to keep the joints tight, besides which the size of the pipe necessary would make it very expensive.

3. To tunnel along the line of the street leading northwest from the lake, putting either a timbered drift or a brick drain and connect it with the city sewers, lowering the water 34 feet by so doing. The distance would be 2,000 feet for the tunnel alone. The city drains not being designed for this extra flow, trouble was feared.

4. To deepen the stream of the outlet as far as possible and tunnel the rest, which would only lower the water about 28 feet, as the grade would be nearly a mile to ditch and tunnel.

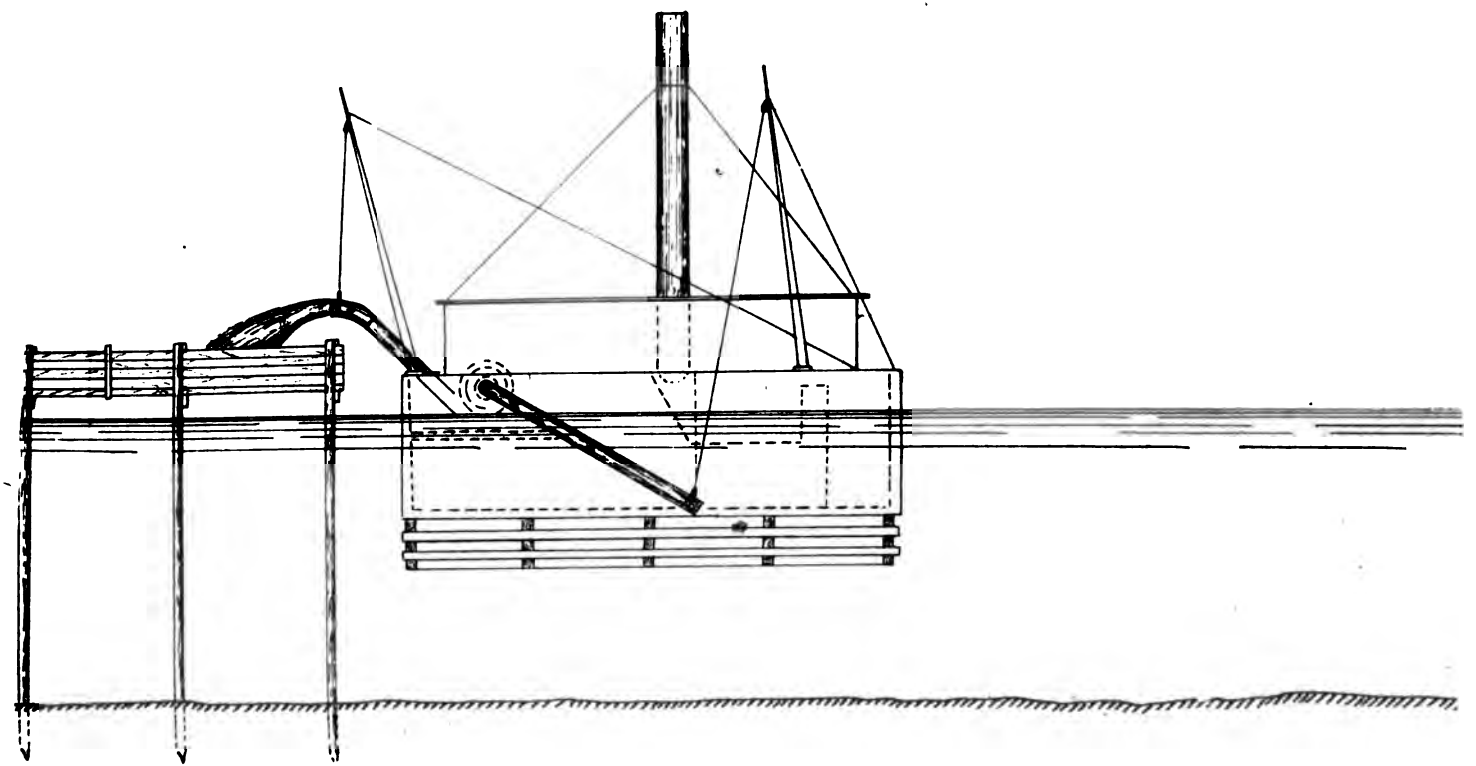
The plan of pumping was the one finally adopted because it was apparently the quickest and cheapest method for disposal of the water, which had become a serious menace to the mines now developed to a considerable extent beneath it. Besides, it was thought possible to drain most of the surface water to the outlet economically and the drainage of the lake proper would ultimately be pumped from the mines, when 30 feet additional lift would not add much to the expense.

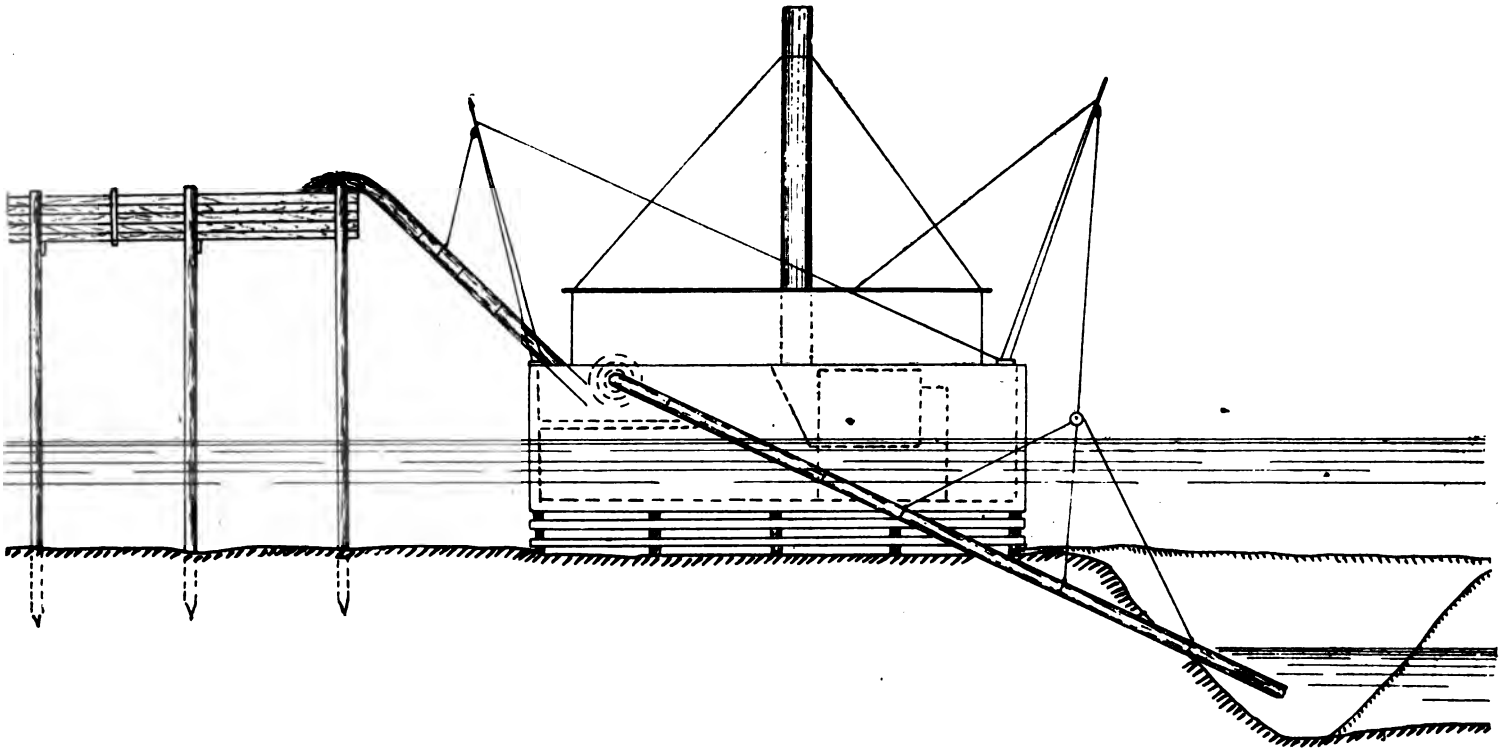
Formal permission to drain the lake was obtained from the city council in March, 1892.

The lake water had been used for city purposes until 1889, but on the water becoming impure from discharge water from the mines and houses around it, the pipes had been extended to the next body of water, Lake Sally, which is 80 feet higher and a gravity system adopted for most of the city, saving a large expense of pumping. The drainage of the lake interfered with no other rights.

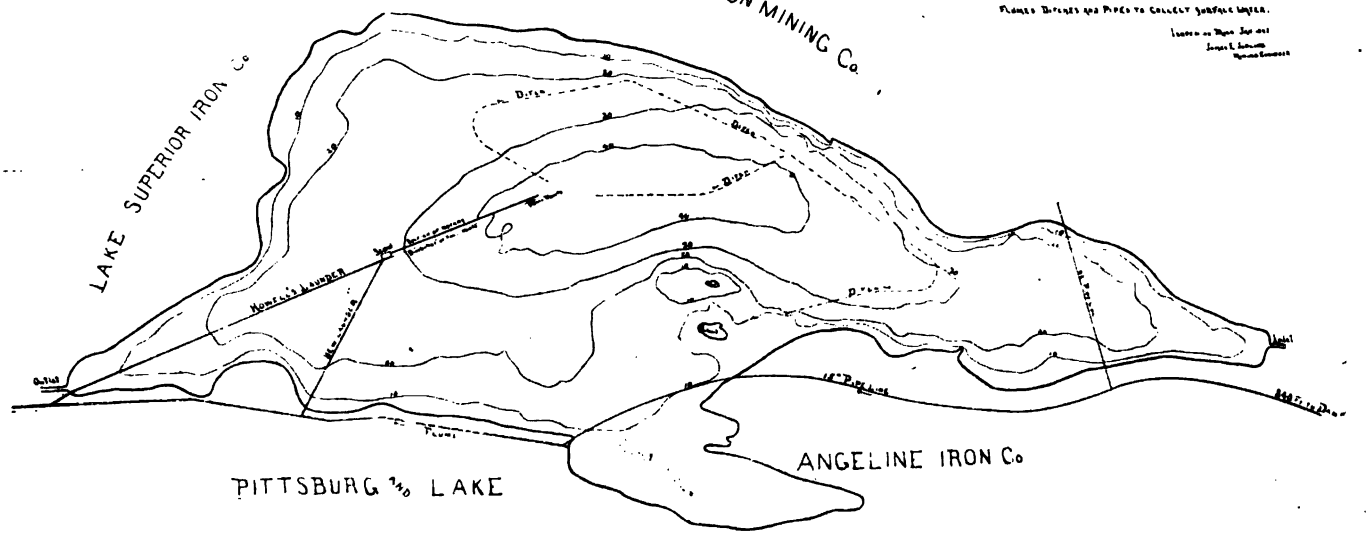
The contract to drain the lake was let March 7, 1892, to D. C. Howell & Son, of New York, who agreed to take out the water in five months from that date.

Their plan of operation was first, to deepen the outlet as much as possible and then pump out the lake by means of a centrifugal pump, the machinery being placed upon a scow which was moved from the shore as the work progressed, until





LAKE ANGELINE.



a point was reached from which the remaining water could be drawn through the suction. A sketch showing the general arrangement of the pump accompanies this article.

In April the scow was built on the north side of the lake where the sand bottom was even though steep and from this point it was launched May 2. The scow which is 24 feet by 48 feet long is substantially built, and rests upon timbers arranged in the form of a crib four feet high to give a good anchorage, the total height being nineteen feet. The plank on the bottom and walls is three inches thick and is calked with oakum.

The machinery consists of a centrifugal pump which was of a special design of Mr. Howell's, having an estimated capacity of 20,000 gallons per minute for a short lift though with a heighth of 45 feet this was believed to be reduced to 11,000 gallons. The suction is 18 inches part of the way, then 20 inches, which is the same as the discharge. The chamber of the pump is 7 feet 4 inches in diameter. It is coupled direct to an Ericsson compound engine which has a vibrating or pendulum character of piston with a shaft giving a rocking motion. The engine has an independent condenser. The motion to pump is imparted by a projecting arm on piston shaft to which the connecting rod is attached, the other end of connecting rod being connected to crank of pump shaft. The valves are non-releasing of the Corliss type. A fly-wheel on the pump shaft 5 feet in diameter carries the crank over dead centers. Its maximum number of revolutions was estimated at 165 per minute and though it is said but 140 strokes were realized during the year of pumping out the water, the engine actually performed this during the second year. The boiler is seven feet in diameter by ten feet long, having 132 three-inch tubes and a steam dome three feet in diameter by three feet high. It is rated at 50 horse power. The steam pressure was from 100 to 110 pounds.

The pump was not started until after the outlet had been lowered. This work was begun in May. The stream from the outlet was found to have a grade of about 7 feet in the first thousand allowing three inches to the hundred feet. This

enabled them to lower the lake five feet. The ditch had to be dug to a depth of 10 feet below the made ground near the outlet and it did not become much shallower until within a couple of hundred feet from the swamp at the lower end. It was dug four feet wide and the sides lined with plank kept in place by posts driven down and by spreaders. There were no planks in the bottom. Considerable trouble was met with in digging this ditch and it was not completed until the middle of June. By this time the lake had filled up half a foot and it took until July 2d to drain off the five feet of water. It was estimated that for part of the time of running out the flow exceeded a million gallons an hour.

A launder three feet eight inches by three feet high at the shore end decreasing to two feet at the pump was built to the scow and rested upon piles which were only worked down, not driven, and a gangway constructed upon which coal was wheeled, and all was ready to pump by July 9. At first the pump only took off about four inches a day, but this was increased to a foot when the lake diminished in area, but there were many delays caused by moving the scow to deeper water and adding to the length of the launder. By September 17, 25 feet had been removed, but by increasing lift the capacity was decreased to 7 inches a day. In the middle of October the scow had been moved to its final position 1,300 feet from the outlet and the suction extended 200 feet still further.

The trouble with the mud now began. It had been supposed the pump would suck a way through the mud which was thought to be principally sand. It was 15 feet deep and found to be the most difficult material to handle. It slid towards the suction which at the same time it undermined as well as the launder, and whereas the contractor believed the work nearly finished by the end of October, it was not until after the middle of December that the companies accepted it. Up to November 1 the pumps had only worked 48 days, the rest of the time being spent in delays described, the launder having to be kept up continually, while the joints of the suction became leaky. A "Y" was finally added to the suction and two 12-inch pipes extended into the mud, the water being only 1 foot deep. Mr.

Howell finally left at the end of December and it was popularly supposed he had made a profit though not a large one. The amount of coal burnt during the year was 651 tons. The water in the lake had been lowered 45½ feet which showed that considerable mud had been pumped as the deepest sounding in 1891 had shown only 41 feet of water.

The pump was stopped about December 20, and during the winter the water was allowed to accumulate. To put the suction and discharge in good condition a road was constructed. The discharge was planned to go the shortest line to the shore, some 675 feet distant and the foundation was made of 4 to 6 layers of brush interlaced 32 feet wide. On top of this, poles were laid corduroy fashion; upon these 3-inch planks were fastened to 5 stringers 8 by 12. Piles were driven every 25 or 50 feet along the sides to prevent movement. The launder, 3 by 3, was hung from a trestle work resting on the planks, and had a grade of 2¾ inches per 100 feet; the launder was screwed up by the bolts whenever a settlement occurred. The road for the suction to rest upon was 16 feet wide, but was not built quite so substantially.

On March 18, 1893, 3 No. 10 Knowles pumps having a capacity of 1,230 gallons per minute were started. The water had risen 5 feet 9 inches during the winter, but from this until April 3 it was lowered 3 feet 6 inches. The water with that from the breakup began to gain in spite of the pumps and it raised continuously until April 24 when it had reached a height of one foot above that of March 18. The rotary pump was now started and the water was reduced about 4 inches a day and on May 19 the same level was reached as when Howell left off. After May 26 the rotary was not again used, but either a duplex Worthington 14 by 10 and ¾ by 10 inch stroke or a No. 10 Knowles pump have been in constant use ever since.

Experiments were now made to get rid of the mud. Many were the suggestions for draining or disposal of the mud. Among the former may be mentioned a few plans that were tried; the use of perforated suctions as used in artesian wells, having a great number of small holes enlarged towards the inside, different guage of holes were used, but they merely

choked with the mud; the sinking of an iron caisson to the ledge from the bottom of which the water could be taken, this struck boulders at a depth of 25 feet before getting down and became fast.

A well 40 feet square solidly built of timber was recommended. This was to have been sunk in the mud to the ledge but was not tried.

For disposal of the mud it was suggested to keep agitating it by pumping in a small stream of water, this was done and is continued at times when it is necessary to clear the suction; by this means, and also during the summer (1893) when men were employed to stir up the mud, large quantities were removed.

A pump such as is used in dredging channels was also spoken of, the mud to be deposited in worked out mine pits. Also it was believed preparations could be made underground to receive the mud but there were many objections to this scheme.

Many experiments were tried and much money expended apparently to little purpose, but by watching the result of constant pumping it has been found that in two years the lowest point of the lake was reduced 6½ feet, and in the other two years up to this date it has been further reduced 5½ feet, making it twelve feet deeper than shown by the soundings in 1891. The water has not been allowed to accumulate since 1893, and the pumps have not been stopped more than a day or so at a time.

To take care of the surface water a launder was built along the shore on the south side, and in 1894 a dam was constructed in a ravine 840 feet beyond the inlet of the lake, from which a 15 inch pipe leads to the flume. Ditches have also been dug across the lake bottom to facilitate taking the water to the pump, the mud having been drained sufficiently to do this.

The problem of the mud has been solved in a way by the necessities of the companies now mining ore beneath it.

Where the mud is not as deep as in the center, rooms have been worked out in the ore, and while the ore is being extracted the overburden is carefully propped up with timbers. The ore in the room having been taken out the support-

ing timbers are blasted together, bringing in the surface by its own weight. The sand mixing in with the timbers generally forms a strainer for the mud, draining out the water, after which the mud can be again brought in or caved down as each successive slice is undermined. Precautions are always taken to prevent the mud from running into other parts of the mine. At times this system has given trouble but on the whole it is a success and along the edge of the basin of mud a number of these caves or pits are now to be seen.

When the basin is undermined the water that falls upon it must be taken care of by the pumps in the mines, while all water that can be caught at a high enough level will be discharged by a ditch into the outlet. At present one man on each shift attends to the pump except at the time of heavy rains, and about 40 tons of coal a month are used.

THE CHIP BASKET.

H. C. PEARSONS.

Gentlemen of the Michigan Engineering Society:—The "*Chip Basket,*" as invented by our friend Skeels, is a great institution. So I offer one for your consideration, asking forbearance for the smallness of the basket, and the smallness of the chips.

1. Limit of Road Gradients.

Our engineers, so far as I know, have not given us any means of finding the limit of grade that may be allowed on a road whose "traction" is known.

To illustrate, suppose we are building a road to be paved with blocks of stone,—on which the traction, per gross ton, including weight of the carriage, on a level, shall be forty pounds.

Then what is the limit of grade we may introduce on that road, without impairing its efficiency?

Solution. It will be remembered that the horse is supposed to be able to exert a pull of one hundred pounds, during eight hours out of ten daily, without physical impairment, and that he has a reserve energy by which he can, for a few moments, at a time, exert twice his ordinary or normal effort, having frequent intervals for breath.

Then, dividing the efficiency of the horse, one hundred pounds by the traction of the road per ton, forty pounds, we have:

$$100 \div 40 = 2\tfrac{1}{2} \text{ tons} = \text{the load.}$$

Then, ignoring the difference between the horizontal length and the slope length of the road, which we may, since it is less than $1\frac{1}{4}$ inches on a five per cent grade, and bearing in mind that the reserve force of the horse is supposed to be equal to that of his normal work, except in duration, *we have merely*

to find the ratio of the reserve force, to the extra load, for our gradient. Thus,

100÷(2.5 tons=5,500 lbs.)=.0182=gradient.

That is to say, 1.82 per cent, or say one foot ten inches per one hundred feet is the steepest grade that we can introduce on that road without impairing its efficiency; and that for distances of not more than one hundred to two hundred feet,—for, as the horsemen say, the horse must have frequent intervals of getting his breath when making extra effort.

Again, Suppose we are building an earth road, on which we hope to reduce the traction per ton, on a level, to about a mean between that of gravel road of a traction of one hundred and forty pounds per ton, and that of an ordinary earth road of two hundred and forty pounds traction, or say we wish to reduce the traction on our earth road to one hundred and ninety pounds per ton, what is the limit to our grades?

Solution. As before, dividing the energy of the horse,—one hundred pounds, by the traction in pounds per ton, gives:

100÷190=.5262 tons=the load on a level.

Then, to find the relation of our reserved force, one hundred pounds, to our extra road, we must not forget the weight of our horse, for that is an important factor on the steeper grades.

Our extra load for a level was found to be .5262 tons, or 1,157 pounds. To this we must add the weight of the horse, say 1,200 pounds, then we have

100÷(1,157+1,200)=.0424=gradient.

That is to say, we must not make our grades steeper than 4¼ feet per hundred, if we wish to preserve the maximum efficiency of our road, without adding weight of horse, it is 8.6 per cent.

The results above brought out, illustrate the law that requires us to make our gradients less, as we make the traction on our roads less. And it will be seen, that, on a level there is practically but one element of resistance,—resistance to rolling,—most improperly called "rolling friction." On

the grades, we must add to the normal load, that part of itself, indicated by the slope ratio.

2. Legislation Wanted in the Interest of "Better Roads."

This is the burning question of the day,—and what shall it be.

a. Some think we should get rid of the modern pathmaster, as he is deemed the leak through which our road funds are so recklessly wasted.

b. Others think that we should dispense with the labor part of our road tax, and substitute therefor an all money tax,—as then we get something done.

c. Still others would merge our road funds into a State fund,—changing the mode of our assessment to correspond, and

d. Some want a *county engineer*, appointed by the board of supervisors, to have charge and supervision of all the roads in the county,—the township commissioner of highways to be appointed by the township board, and the pathmaster to be appointed by the township highway commissioner, all to have a term of service not less than two years, or preferably on the civil service plan, to give them experience.

I offer a brief discussion of the several plans of mending our road laws.

a. With regard to the pathmaster, we cannot spare him; we might as soon look for a steam shipmaster to dispense with his wheelman, or a ship engineer to dismiss his fireman, as think of doing without our pathmaster; but we do need to get rid of the idiotic wastefulness of the manner in which he is required to do his work. The wealth of a Crœsus would not suffice to conduct any business to a successful issue, if conducted as we do our road work. Ourselves, and not the pathmaster, are responsible for the shameful and superlative wastefulness of our road funds.

Having found a man of fair intelligence, we should keep him, as other people, not insane or idiotic, keep their servants, till, with experience, and training and observation, he becomes

a useful and valuable expert; then give him a salary that will keep him.

To appoint a man this year, who has no fitness, no schooling, no training for his work, then to set him to work without plan or specification, or method, or appliances, or instruction of any kind, further than to warn out his men and do a certain number of days' work on the road, and then to repeat the same process next year, and so on for years, is a kind of stupidness not paralleled in the world outside of the State of Michigan. When we shall have modified the laws as above indicated, we shall have stopped the leak complained of.

b. With regard to doing away with the labor tax, we must go slow. It would, indeed, be very desirable to have all money to build and repair our roads with. But to impose an all money tax for our road fund, would certainly be a hardship on some of the taxpayers; for, with some of them, the expense of turning their labor into money, is a considerable part of the tax.

c. The idea of merging our road fund into a State tax, is only another way of building our roads with an all money tax.

With the county engineer asked for by class (*d*) of our reformer, and with the part money tax, and the trained officials and operative asked for by them, the all money tax is not at all a necessity, however pleasant it might be to have such a fund to work with.

A portion of our taxpayers will kick on that idea with the desperation of a vicious mule. When we fail to consider the taxpayer, we reckon without our host, and we need not be surprised to find ourselves stalled when we least look for such an event.

This scheme is too far reaching in the amount of legislation required; is too radical; requiring too much time. Moreover, the well-known views of our new Governor are directly against such a move. It is vain to look for relief in that direction.

d. The plan proposed by class *d* of our reformers, or something equivalent, appears the most likely to meet the minds of the people. The new road law, so called, and under which

some counties are already at work, is a move in the right direction; but it is only a short move. It provided competent supervision for only a part of the roads in the county, while this provides for the township roads as well. And here a suggestion offers itself, viz.:

Instead of having the county road commissioners select their engineer, merely for the roads they build, let the law be amended, so as to have the board of supervisors appoint an engineer to have the supervision of all the roads in the county, then our chief want is supplied.

I have discussed this question more at length in the *Grand Haven Courier-Journal* of January 1, 1897, and sent copies to some members of our association and to some members of the legislature, with a view to further consideration.

It is hoped that the members of the Michigan Engineering Society will coöperate with the friends of the *"Good Roads Movement"* in the legislature, to the end that our road laws be modified to conform, as nearly as may be, with the ideas outlined in the above discussion. Our present road laws, though not what we would have them, are yet on a good plan; yes, decidedly good. They want mending up in a few places, to correspond to the wants of a fast growing country, when we will have a system of road laws that will meet all our wants. *Who will prepare a bill?*

An early and and vigorous action will be needed to get legislation during the current session.

ENGINEERS AND THEIR RELATIONS WITH CAPITAL.

H. G. ROTHWELL, C. E. AND M. E.

When we review the centuries that are passed, we cannot but be struck with wonder and astonishment at the progress science has made in these immense pages of the past and what it has done towards humanizing and civilizing the human family and contributed to their necessities, comfort and wealth. Perhaps it may egotistical in me to attribute to the engineering profession the largest share in accomplishing these results, but in granting it first place I don't by any means wish to disparage the church, medicine and law, for their contributions to the general welfare of the human family. The church by its influence has brought man from the savage state to a better understanding of what he owes toward his fellow man; the science of medicine and surgery has been the means of curing his bodily ailments and strengthening it, and with it the brain, which conceives the thoughts and perfects the plans which have done so much to make life pleasant, and remunerative, not only to himself but to his fellow man; the law also has perfected him and restrained him in his duties to his fellow man. But the engineering profession has done equally well, for were it not for the brains and skill of the engineer, man today would be unable to accomplish one tithe of the things that go to make life both a pleasure and a profit, and the engineer would be equally powerless, were it not that the man or men with large wealth, had the speculative and progressive spirit to aid him in the most necessary material (money) in the carrying out of his designs and plans, and the successful accomplishment of these designs and plans have correspondingly paid back and increased the wealth that helped it. This tends to show that the interests of one are intimately connected with the other for their mutual benefit, and that it is as necessary for the engineer

to study the interests of the capitalist as it is for the capitalist to inform himself of the designs and plans of the engineer, and to be guided by his technical knowledge of the part that relates to his profession. This technical knowledge should be, on the part of the engineer, most complete in its details, and on this account engineers should specialize their work and make one or two branches of their profession their special study and by this means acquire a thorough knowledge of these branches of his profession, by adding to the general training, which should be alike for all those who enter the calling. It is necessary for him to carry his work in particular sciences to a higher plane. These special fields, as they at present appear, may be enumerated as follows: Mechanical, electrical, marine, hydraulic, topographical, and mining engineering, and the field is large enough in any one of these branches to give the student all he is liable to do to become proficient in them. Each has its own particular line of study and each cuts a large figure in the progress of the day. Capital should also be careful in choosing their engineers for their special adaptation for the work they want him to perform, and by this means secure the best results. No man can acquire all the technical knowledge in the world. It is an advantage to have specialists, and engineers understand that perhaps better than others. When an engineer is called upon to design something a little out of his line, he should frankly call in advice upon the subject. I do not think there should be competition among professional men. I do not see any more reason for seeking competition among professional engineers in the matter of a design in the ordinary course of work than for seeking a competitive legal or medical opinion on a matter; it would be identically the same proposition. If we are going to make a profession of engineering, we must put a man upon a professional elevation, and seek his opinion, just as we would seek a medical or a legal opinion. In looking over the engineering works of the centuries, we have opened to us a vast book of knowledge—we see various works and structures, many of which are today models of their kind, and the details of which can hardly be improved on; others again,

are models of man's folly, some were so vast in the greatness of design that it was not until long after their completion that men really began to appreciate their greatness or worth; others again are just as noted failures, sometimes in faulty construction and sometimes for want of adaptability to the purpose for which it was designed. A railroad's use and its profitable maintenance, may very largely be destroyed by bad location or expensive grades, long trestles, expensive bridging, etc., etc., which by an extended and intelligent study of the conditions, could in great part be avoided. A canal that in one place might prove a marked commercial, as well as engineering success, under other conditions may be a total failure, and so on. The sands of time are strewn with many such wrecks, monuments of the folly of man. It is for these reasons that the specialist is found so necessary that his increased knowledge may be taken advantage of.

In mechanical engineering, quoting from Bourne, in his splendid work on the "Steam Engine." The present time is one of movement and apparently of impending revolution in the means of obtaining motive power. The steam engine, after having for nearly a century, been the only efficient thermo-dynamic motor, and after having remained without any change in its principle of action and even without any striking improvement in its details since it was dismissed from the hand of Watt, is now I believe on the eve of supercession by simpler and more economical machines, and although among a host of competing contrivances, we cannot yet single out any one which we would be warranted in doing homage to as the prime mover of the future, and although such an engine has probably yet to be invented, still there is no reason to doubt that it will before long appear. The number and variety of the schemes that have been put forward for obtaining motive power from heat, show very clearly the existence of a widespread perception of the enormous faults of the present steam engine, and of the exigent need that exists for the introduction of some better contrivance to take its place. These improvements and inventions belong properly to the domain of the mechanical engineer, and with his

skill properly backed up by enterprising capital, we will, I have no doubt, soon enjoy the benefits of having the greatest amount of power from a given quantity of heat. In electrical engineering, a very large and important field is opening up and one that is developing very rapidly with marvelous results. The power of electricity to do heating under every variety of conditions, to handle all varieties of the atoms of matter and to operate as a chemical and physical agent directly, in and through all parts of the living system, necessarily gives it an almost unlimited field. Not only can it supply light by heating to brilliant incandescence either carbon or platinum, but it can no less readily fill any demand for heating. Its immense and irresistible energy attacks with complete success the difficulties of smelting and of the reduction of refractory ores, and with more than the power of a miracle, it comes to the help of the surgeon and the physicain on lines of medical efficiency almost coincident with those of creative energy. The story of brilliant engineering at Niagara designed to turn the most magnificent and impressive terrestrial natural object into a source of power, transformed from the force of falling water into that of electricity and transmitted to a distance for either electric lighting or manufacturing, employing electric motors, has become one of the most marvelous in the history of applied science. Nearly twenty years ago one of the most eminent of German engineers, Sir William Siemens, took occasion to visit these falls and with the natural impulse of a scientific mind, he was struck with the inexhaustible manifestation of mechanical energy which the stupendous rush of waters presented. The dynamo electrical machine had just reached (partly through his genius applied to the problem) the perfection which made it available in the application of electric energy. The idea came to him that the power of the falls might be tapped for operating a colossal series of dynamos, whose conducting wires should transmit its energy to places miles away. Capital came to his aid and the Cataract Construction Company, representing not only abundant capital, but the best engineering ability of the country, have made the original idea into a crowning success.

There is practically no limit to this form of transmission of power and the country is full of water falls where nature has been wasting her energies for centuries, only awaiting the purse of the capitalist and the skill of the engineer, to transfer their power over the whole country to help labor and run our mines, factories, and perform the many duties of power, even to the cutting of our grain.

MARINE ENGINEERING.

The rapid strides in marine engineering have been most marked; the possibilities of steam were known to the ancients; its applications were described by Hero 130 B. C. Roger Bacon in the fourteenth century made some experiments, and Blascode Garvay constructed a rude steamboat at Barcelona in 1543. Later Papin built a steamboat in Germany, which was of sufficient importance to arouse the superstitious dread or conservative opposition of the bargemen, who destroyed it. Many others gave their attention to the subject, but Jonathan Hulls of Liverpool appears to have been the first to reduce the marine engine to actual practice. In 1737 he published a pamphlet describing his stern wheel boat, accompanying it with an engraving which is yet in existence and from which it would appear that it was capable of towing a large vessel. It is a little curious that the first form which the invention followed, was that of the stern-wheel. Those who think that the first thought is the best, may find confirmation of that opinion by observing that not only is the stern-wheel widely used on the rivers of the west today, but stern propulsion under a modified form is, after many experiments and a long trial of lateral propulsion, the plan upon which the world has finally settled for marine navigation, and the marine engineer has so studied out the lines for his ships; combining his knowledge with the mechanical engineer, that the results have been most marvelous, as illustrated by the achievements of our ocean racers, our immense ore carriers on the lakes, another type, models for the economical carrying of freight, and the possibilities for still further improvements, as illustrated in the modern yacht. Were it not for the efficient aid

of capital, their immense strides could never have been accomplished, and that still more wonderful achievements are yet among the possibilities, go without saying.

HYDRAULIC ENGINEERING.

This is a large and rapidly growing field, and one that cuts a large figure in the economics of the future, the utilization of our, at present, waste water powers, our systems of irrigation and water systems for towns and cities, also for hydraulicking our auriferous gravels. There is much to be done in these fields and with the aid of capital judiciously expended, there are many fortunes in it; the storing and distribution of water under pressure, furnishing immense stores of power at present comparatively but little used and accompanied with electricity and the electrical transmission of the power thus stored, will make properties which under old methods are unable to meet expenses, profitable ones and bring waste lands to be gardens of verdure. The engineer has much to do with the success or failure of these schemes and as most of them require the immense expenditure of capital, all surveys, plans and calculations, not only of the power, but of the earning capacity of that power, when applied, should be gone over with the greatest care, and here topographical engineering comes much into play. As in railroads, canals, and water courses, the judicious location as to grades, and to prevent washouts by extreme floods, and the most effective use of the supply and power obtained are all factors in the successful operation of the system when constructed. We now come to

MINING ENGINEERING.

When we come to consider the large number of minerals which nature has stored up in her treasure house for the uses of mankind, we come to a realization of the enormous amount of study that has to be accomplished to convert them from their original constituents to the various uses man has been able to put them to and those which are yet undiscovered.

The art of mining these various minerals, varies with the conditions surrounding them, as do also their methods of treatment to separate them from their impurities and large amounts of capital are required for these purposes. This has been furnished both wisely and unwisely, for to those who want to rapidly get rich, the mining field has been a very great attraction and one where the opportunities are indeed great. This has reverted disastrously in a large number of instances, principally from the ignorance or cupidity of the original promoters of mining schemes, who, taking advantage of the credulity of the people, foist their visionary schemes for immense wealth upon the people with carefully prepared prospectus, unreliable mine report and handsome maps. I would say here that there is no more legitimate business in the world than mining when it is legitimately carried on, and vice versa, for it has all the fascination of the gaming table, but this does not apply when men take hold of it as they would any other regular business. On account of the fascination mentioned, many men with but small means, invest in mining stocks of new and visionary mining and exploration companies, whose officers are dishonest and whose properties are oftentimes worthless, because the skill employed in their location is valueless, and strange to say, this class is able to get more employment in mine exploration than in almost any other. This is helped along by the general ignorance of the business of mining amongst the average investors in it. This is not surprising, for were this knowledge easily acquired, there would be no use for my foregoing remarks or for the technical training of engineers for the purpose. There must be also a large proportion of sound practical knowledge combined also with the technical, and it is no more reasonable to suppose that the required knowledge, as regards the value of a mining property, is to be obtained from the learned professor of other sciences, who is dragged from the seclusion of his study and put underground to be made miserable with candle grease, than from the so called practical miner, who having beaten a drill for a few years, is prepared to dogmatize also on facts, figures, theories and conclusions. Such

men's reports are often very misleading and being sprinkled plentifully with the general technical terms, such as the true fissure vein; increasing in depth; increasing richness as depth is attained; junction of veins; ore in sight; proximity to a rich mine; failure from mismanagement, etc., etc. Now all these terms are good when used in the right manner and not indiscriminately for the purpose of misleading the public and in a way to imply more than they actually mean. The location of mining properties is one that calls for the best knowledge of *Technical Mineralogy.* Some metals are found native and in some degree of purity, as in the cases of gold, silver, copper, mercury and platinum, but frequently native metals appear under such colors and even forms that the discoverer must possess more knowledge than any one usually possesses who has seen the metals in the arts only. The great mistakes in mining and those most frequently made are the hurry most mining companies get into to get up some class of reduction works before the mine is sufficiently developed, also in mistaking the character of works most desirable for the conditions of the ore to be treated. There has been many a ten stamp dividend paying mine swamped under a forty stamp mill. The capacity of a mill can always be enlarged, but the money expended in excess of capacity is forever lost, and what could have been made a paying property is changed into a cause of worry, anxiety and disgust, to owners, manager and men.

The old Latin proverb, "Festium Lente" (hurry slowly), is most applicable to mining enterprises. It would be better for the capitalist who is about to invest in mines to call in the services of the engineer before he has irretrievably swamped himself in his enterprise, instead of afterwards, as he too often does. The technical and practical experience of the engineer and superintendent added to the good business sense of the investor, will not only prevent mistakes, but on account of their conservatism, make a successful business enterprise from the start. The management of a mine is, next to having a mine to manage, the most important part of it, and requires not only skill in mining, but a close watch after the expenses.

There has been a large number of good mining properties spoiled by expensive management. It is a fact that many a good mining property is non-productive today from lack of capital to operate it profitably. Nearly all our mines are found by men who have not hardly a dollar to work them, and hence when properly exploited, there is a large and remunerative field here open to the capitalist, and although there are certain risks to run, so there are in all business, and they can be reduced to a minimum by a proper care being used in the selection of not only the property, but also of the men to operate it.

SOME NOTES AND OBSERVATIONS.

A. L. WESTCOTT.

Tests of the Torsional Strength of Cold Rolled Steel Shafting.

The Department of Mechanical Engineering at Michigan Agricultural College is fairly well provided with apparatus for the testing of the strength of materials, and work of this character comprises a part of the regular laboratory practice of each student. It is the purpose of this paper to describe a few experiments that have been performed along this line that are believed to be out of the usual line of laboratory experiments.

The tests of materials commonly made at M. A. C. are the tensile, compressive, and transverse strength of iron, steel, and cement. Some time ago it was thought desirable to make some investigations of the torsional strength of round iron and steel, and for that purpose a simple machine was designed and constructed, capable of testing a bar of 1 inch or less diameter.

The sketch, Fig. 1, indicates the principal features of the machine. The lever arm at one end of the test bar, and the ratchet wheel at the other, are keyed on with sunk keys.

A number of tests of 1 inch cold rolled steel shafting were made, which were quite successful, and the results of these tests are as follows:

In the first experiment weights were applied at the end of the lever arm up to three hundred and forty-five pounds. The key seat at the lever arm end failed by crushing at the side. The key was $\frac{3}{16}$ of an inch thick, and the length of the lever arm was twenty-four inches. The torsional twist of the shaft was measured over a length of forty-eight inches, and showed a nearly uniform rate of twist of about 5.6 degrees per one hundred pounds weight. Calculations of the modulus of elasticity for shearing made from these observations gave an aver-

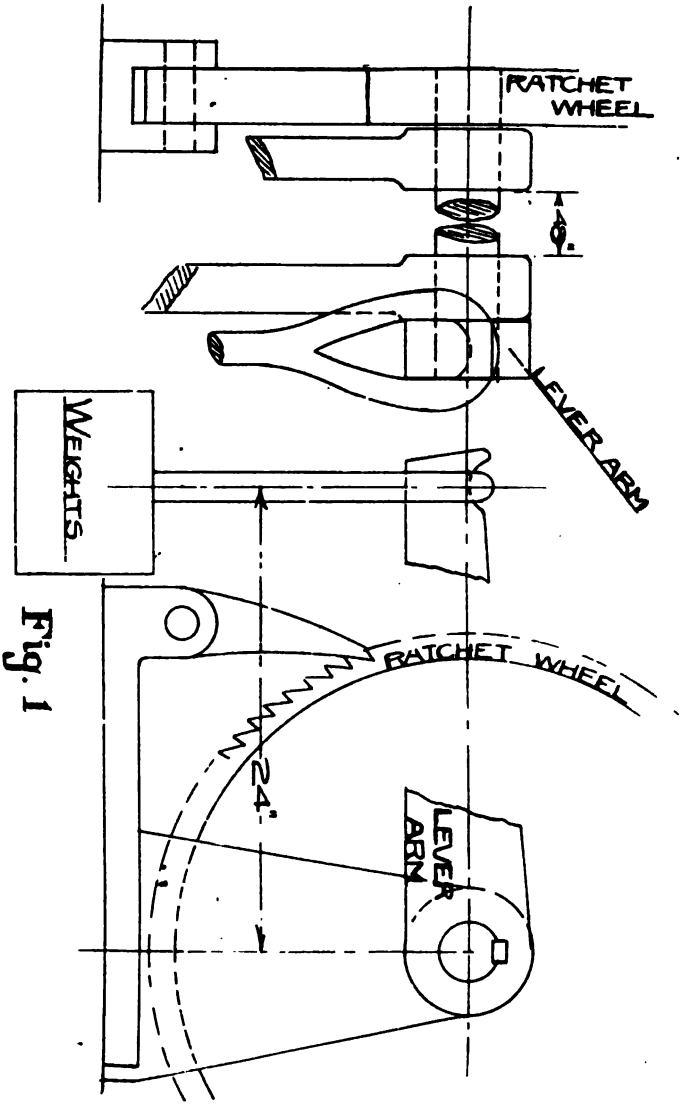

RATCHET WHEEL
4"
LEVER ARM
WEIGHTS
RATCHET WHEEL
24"
LEVER ARM

Fig. 1

age value of 11,700,000 pounds per square inch. On the theory that the modulus of elasticity for shearing is $\frac{3}{8}$ of the modulus for tension, this would give a modulus of elasticity for tension of 29,250,000 pounds per square inch. The twisting moment corresponding to three hundred and forty-five pounds at a leverage of twenty-four inches is 8,280 inch pounds, and the maximum shearing stress per square inch was 42,000 pounds. There was no indication of passing the elastic limit.

The second experiment was made to determine the holding strength of a set screw fastening. The weight arm was fastened to the one inch shaft by a $\frac{3}{8}$ inch set screw, with cup shaped point, the key being removed. Ten pound weights were applied until the set screw slipped. The screw held with thirty pounds, or with a torsional moment of seven hundred and twenty inch pounds, but slipped with forty pounds. Considering the screw and the friction on opposite side as a couple, the tangential force exerted by the screw corresponding to a torsional moment of seven hundred and twenty inch pounds, was $\frac{30 \times 24}{1} = 720$ pounds. Allowing 10,000 pounds per square inch as the safe shearing strength of the shaft, and supposing two set screws to be used, and a factor of safety of three for the set screws, we have the following:

The torsional moment of one inch shaft corresponding to a shearing stress of 10,000 pounds per square inch is 1,970 inch pounds. The torsional moment exerted by two $\frac{3}{8}$ inch set screws, $\frac{2 \times 720}{3} = 480$ inch pounds. The ratio $\frac{480}{1970} = .24$. That is, upon the above assumptions, two $\frac{3}{8}$ inch set screws are capable of transmitting .24 of the safe strength of a one inch shaft. For larger sizes of shafting we would have the safe torsional strength of set screws proportional to the diameter of shaft, while the safe strength of the shaft varies as the cube of the diameter. So that for larger sizes, the ratio of the one to the other is $.24 \frac{d}{d^3} = \frac{.24}{d^2}$, where d is the diameter of the shaft. Of course the above applies to $\frac{3}{8}$ inch set screws only, and further experiments should be made with other sizes.

The keys in the shaft having proved insufficient in the first experiment, they were discarded, and new and larger ones were fitted, being about $\frac{3}{8}$ of an inch square, and sunk into

the shaft $\frac{1}{8}$ of an inch, measured at the side. The keys were forged from an old file. The shaft was then tested to the breaking point, the break occurring at one end just outside of the bearing, and across the key seat.

The shaft was of course weakened by the key seat, and the test does not by any means represent the ultimate strength of the solid shaft.

The breaking load was four hundred and ninety-five pounds, giving a torsional moment of 11,880 inch pounds, and a maximum shearing stress in the body of the shaft of 60,400 pounds per square inch.

The torsional twist was measured, as before, and increased very nearly in direct ratio to the load up to a load of three hundred and ninety-one pounds, when the elastic limit was passed. The torsional moment at the elastic limit was 9,402 inch pounds, and the maximum shearing stress was 47,800 pounds per square inch. The twist of the shaft in a length of forty-eight inches was $22\frac{3}{4}$ degrees at the elastic limit, and $65\frac{1}{8}$ degrees at the breaking load. The keys and key seats were undamaged, and the experiment shows that a sunk key, if made of good liberal dimensions, is amply strong to strain the shaft far beyond the elastic limit.

Adhesive Strength of Cements.

Considerable attention has been paid in the past to the testing of cements with regard to their tensile strength. As the strength of a foundation to resist strains other than compression is determined by the adhesive strength of the mortar rather than by its tensile strength when the latter exceeds the former, tests of the adhesion of cements to brick and stone are seen to be of importance. Having no special apparatus for making such tests, the following method was tried with some success. Three bricks were cemented together, Fig. 2, and after allowing the cement to set for one week, the test was made by applying the load as indicated in the sketch, until the cement sheared off of the bricks. Several tests were made in this manner, with the following results :

No. 1. Fire brick and Portland cement; set in air, and tested at the age of one week. Breaking load, 5,500 pounds, or 150 pounds per square inch.

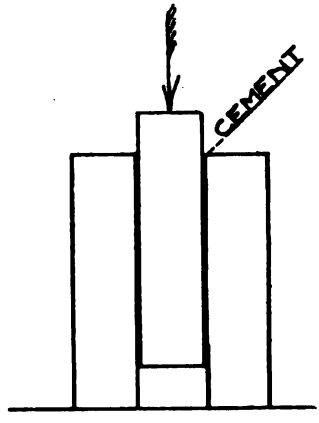


Fig. 2

No. 2. Fire brick and Portland cement, age one week. One brick sheared off at a load of 6,680 pounds, or 155 pounds per square inch. The other brick was then sheared off with a load of 3,080 pounds, or 139 pounds per square inch.

Average of three tests of fire brick and Portland cement: 148 pounds per square inch.

No. 3. Common brick and Portland cement; age one week. Breaking load, 3,080 pounds, or sixty-two pounds per square inch.

No. 4. Common brick and Portland cement; age one week. Breaking load, 2,000 pounds, or fifty-one pounds per square inch.

Average of two tests: 57½ pounds per square inch.

The above described experiments give the adhesive strength of Portland cement when subject to shearing stress. In order to test the adhesive strength when subjected to a stress perpendicular to the surface, the following experiment was tried:

Three bricks were cemented together, Fig. 3, and subjected

to transverse stress, as shown. C. D. is drawn through the neutral axis of section A. B. The normal stress at point B. is equal to the sum of two stresses,—the maximum stress due to the bending moment of the reaction at support R., about

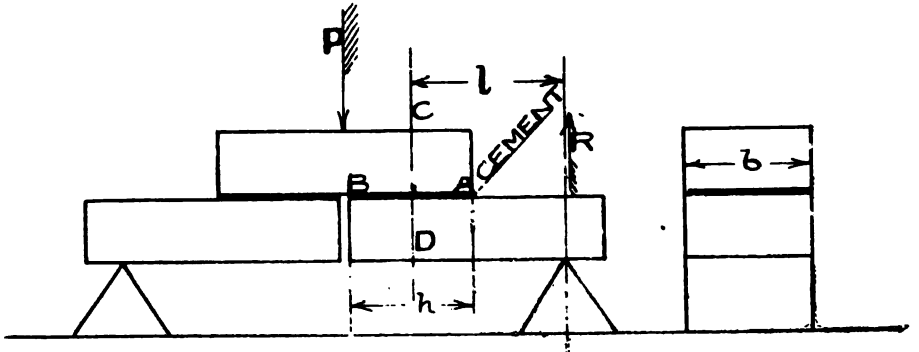


Fig. 3

the neutral axis, and the uniformly distributed stress over section A. B. due to the reaction R. Denoting the first of these forces by p^1, and the second by p, we have:

Therefore $p + p^1 = \frac{3}{b}\frac{Pl}{h^2} - \frac{P}{2bh}$.

Only one successful experiment was performed in this manner. Three paving bricks, cemented with Portland cement, and tested at the age of one week, failed with a load of 750 pounds, which gave, substituting in the formula, $p+p^1 = 72$ pounds per square inch.

These bricks were hard and glazed on the surface, and were more like the common bricks tested than the fire brick.

The result of this experiment indicates that the adhesive strength when tested perpendicular to the surface, is not materially different from that when tested by shearing. The experiments on cements described above were performed by members of the class of '97 in the course of their regular laboratory work.

MODERN STEAM POWER PLANTS.

BYRON E. PARKS.

The title selected for this paper may be to a certain extent misleading. The mind of the engineeer will naturally associate with it, high steam pressures, and their attendant water tube boilers, compound or triple cylinder expansion engines, independent air pumps and condensers, and all the minor appliances which go to make up a high-grade modern steam plant. It is not, however, my purpose to discuss in detail this particular type of plant, but to confine myself more particularly to the small and medium sized plants, such as are usually met with in our Michigan manufacturing establishments, and in a general way to consider some of the mistakes made in their design and management, which appear to be common to many of them.

Judging from my own experience and observation there are comparatively few of these plants that come up to the expectations of their owners as regards economy in fuel consumption. This may be, and is, often due to a lack of proper management in its operation. But more often it is due to a disproportion of the component parts of the plants to each other, and of the whole to the work it has to do, sources of loss which no amount of careful management on the part of those in charge can overcome.

The cause of this disproportion is generally due to a lack of the accurate knowledge, and full understanding on the part of the owners of just what type, or size, of boiler, engine, and other appliances, going into the plant are best suited to the requirements of their particular case.

The idea of employing a competent engineer to study their needs, and prepare plans, specifications, and supervise the construction of their plant, is either not thought of, or considered a useless expenditure of money. And yet in nearly every case he could save to the buyer on the first cost of the

plant all that his fee would amount to. The greatest saving however, to the owners, would make itself apparent in the higher efficiency of the plant as shown by the comparatively low fuel consumption per unit of steam supplied or power developed, and this saving would be continuous throughout the life of the plant.

On the contrary, instead of employing an engineer, the owners, who are generally the buyers of these small plants, rely upon the information obtained from catalogues, and the salesmen representing the different manufacturers. The information thus obtained is no doubt correct so far as it goes. But it stops short of giving the buyer just the specific knowledge which he most needs, and such that it will enable him to determine just what type or size of boiler, engine, or other appliance is best suited to his requirements.

The buyer is therefore placed in the position where he *must* decide for himself these important questions. Without any accurate knowledge of steam engineering, the selections made by these owners of steam machinery is seldom that best suited for the class of service for which it is bought.

The writer has seen high priced water tube boilers in places where a much lower priced multitubular would have served just as well, and shown just as high economy in fuel consumption.

Another case that recently came under my observation: A manufacturing concern had lately bought and installed a water tube boiler of a well known make. It was thought by those in charge that the boiler was of a considerable larger capacity than their work required, so they decided to "stop off" a part of the grate surface. The grate surface originally provided by the builders of the boiler was thirty-six square feet. This was reduced by covering a strip around three sides with brick to twenty-one square feet. Over this twenty-one square feet of grate area I found them burning 600 pounds of coal per hour, equal to over twenty-eight and one-half pounds per square foot of grate area. This almost equals the coal consumption per square foot of grate obtained with a heavy forced draught. Where the firing is forced to the extent that

this consumption of coal per square foot of grate indicates it cannot be otherwise than very wasteful of fuel. And had not the chimney been of more than usual height and capacity for such a boiler they would have found it utterly impossible to burn enough coal to maintain steam pressures. As it was the fireman was obliged to watch his fire very closely.

Now a word in regard to the usual method of selecting engines, practiced by the owners of these small and medium sized plants. The idea is quite prevalent among the owners of these plants that an engine of the Corliss type is the one desirable feature to be sought for if they are striving for a high economy in fuel consumption. There is another idea which one will often hear quoted, to the effect that "there can be no mistake made of getting an engine too large for its work." Following this opinion the buyer, having no accurate knowledge of just how much power is actually required for his work, thinks he will be sure and get an engine that is *large enough*. The result is that it is not uncommon to find engines running of a rated power double that of the actual work being done. An excessively underloaded engine is never economical in the steam consumption per one H. P. In fact it is well known among engineers that no other one condition is so destructive to good economy as an engine excessively large for its work. The owner of a high grade engine bought under the idea of getting it *large enough* any way is naturally disappointed if in point of economy it is not equal to his expectations. These expectations are generally based on the representations made by the builders, that the engine is capable of developing an one H. P. on a certain steam consumption per H. P. with a certain rated load. And it would undoubtedly do all that is claimed for it if the conditions were complied with.

During the past year the writer has met with quite a number of cases in which engines that would rate at from two hundred and fifty to three hundred H. P. actually indicated, with their maximum loads only from one hundred and twenty-five to one hundred and fifty H. P. All of these engines were of a high grade type, some of them the Corliss and others of a design that usually ranks with the Corliss in grade and economy.

Some of these engines run condensing, and others were run non-condensing, but by none of them was there the economy of steam consumption shown that is usually expected and obtained from the engines of their type under conditions favorable to economy.

THE DESIGN OF STEAM PLANTS.

The problems which present themselves to the engineer in connection with the design of a modern steam plant for a manufacturing establishment are varied and of a more or less complex character, requiring the exercise of a knowledge and judgment of the problems involved which is born only of experience.

He must first estimate the power that will be required to operate the establishment to its maximum capacity. If future enlargements are anticipated these must be provided for, but only within certain limits, unless the enlargements are to come in the very near future, or the economy of fuel and other costs of operating the plant are of no special moment. Having determined the power of the engine required, the next question is that of boiler capacity. If steam is to be supplied only for the engine, then when we have decided on its size and type we have also practically decided the question of how much boiler is wanted. But if steam is required for other purposes aside from that used by the engine, then the quantity must be estimated and boiler capacity provided accordingly.

An excess of boiler power beyond the actual requirements of the work is generally advisable, so that the necessary steam for all purposes may be supplied without any forcing of the fires.

Having decided the questions of sizes of boilers and engine, the next and all important one is as to their type. The solution of this problem is to a great extent dependent on the character of the manufacturing establishment. If there is a refuse available as fuel, its quantity, and whether abundant for the purpose of steam making. When there is no refuse available the cost of coal delivered will be the deciding factor.

In our State we have a great many concerns engaged in the

manufacture of different articles of wood from which there is more or less refuse available as fuel. In some of these establishments this refuse is more than abundant to furnish all the fuel required for steam making, while in others it is limited in quantity and must be used at a high efficiency, if it proves sufficient for the purpose. For a concern having an abundance of refuse available it would obviously be anything but good engineering to design a plant with the view of the extreme economies in the use of fuel.

For another concern where the available refuse is limited in quantity the engineer will endeavor to design a plant to fit the case, that is, he will carefully estimate the thermal value of the refuse available as fuel, and while perhaps not striving for the highest economy in fuel consumption, he will yet endeavor to produce a plant which is economical enough so that the available refuse will furnish all the fuel required. When the fuel is to be coal at a high cost per ton then the engineer is justified in designing a steam plant with the view of the highest economy of fuel consumption, consistent with its first cost. The size of the plant will then be something of a deciding factor as to how far it will pay to go in striving for economy in fuel consumption.

DETAILS OF DESIGN.

Having decided on the power of a steam plant, the first problem in connection with the details of its design is the chimney.

The chimney determines how many pounds of fuel can be burnt per hour, the quantity varying with the kind of fuel in very narrow limits, and also to some extent dependent on atmospheric conditions. The chimney draught is an important factor in the cost of steam production. Hence the importance of giving to it an ample area for the passage of the waste gases of combustion, proportioned to the quantity of fuel that must be burned, and a height that will give a sharp draught.

Some authorities place the minimum height of a chimney at eighty feet for a good grade of free burning coal, one hundred feet and above, according to size, will probably generally give a better satisfaction. The chimney should be provided with

a damper, arranged so that it can be easily manipulated at the front of the boiler. The fireman should be able to regulate the draught with the damper to suit his coal and meet the demand for steam. There are several automatic damper regulators on the market which are excellent devices for the purpose and well worth their cost.

The chimney having fixed the quantity of fuel which can be burned we must now arrange the furnace so that it will do the best work within this limit. Keeping in mind the fact that the draught must be husbanded, its whole force to be called on only for a maximum effort. The kind of fuel and nature of the service will determine the proportions of the furnace. The design of grate is also dependent on the nature of the fuel. The furnace which will be found entirely satisfactory for coal will be found inadequate for wood. Or if to be proportioned so as to give good results with a steady and regular work it may require modification to meet the demands of a sudden and varying load. The area of the grate must vary with the nature of the fuel. If we have a clean, dry, free burning coal or light wood a larger quantity can be burned per square foot of grate, than of other kinds of fuel which from their nature are necessarily slow burning. Wet sawdust or the "spent tan" in tanneries both carry a large per cent of water, consequently are very slow burning fuels, therefore we must have very large proportions of grate area in order to burn them successfully or even at all.

The brickwork of the furnace should have as few openings, doors, etc., as possible, since every break in the band of the brickwork increases the tendency to cracks, which we wish to avoid, as they all tend to lower the efficiency of our furnace. The walls of the furnaces in all places where exposed to the direct heat of the fire should be lined with a good quality of fire brick.

The type of boiler best suited to a steam plant, depends entirely on the efficiency aimed at in its design. If the fuel is a high priced coal the purpose will then be to produce a horse power of work with as small a consumption of fuel as possible, which would mean high steam pressures. For high steam

pressures water tube boilers are always to be advised, if for no other reason than that of increased safety. If the selection is judiciously made, however, the cost of maintenance and repairs will also show a considerable in its favor.

On the contrary if the location and surrounding conditions under which a plant is to operate are such that the higher economies of steam production are not worth their cost, then comparatively low steam pressures are advisable, say seventy to one hundred pounds. For pressures within these limits, considering first cost, maintenance, and general efficiency, for stationary power plants, our old stand-by, the multitubular boiler, is undoubtedly the peer of any type. With the same care given to its design, and that of the setting and furnace proportions which other boilers receive where high efficiency are striven for, it will be found to compare with any of them.

The feed water, before going into the boiler, should always be heated to as near the temperature of the water in the boiler as possible. The best modern practice is to heat the water in an exhaust steam heater to as near the boiling point as possible, and then feed it into the boiler through a live steam purifier. This method will render the worst water almost absolutely pure before it enters the boiler, and at the same time heat it to a temperature equal to that of the water in the boiler. The advantages of heating and purifying the feed water as here described are too obvious to require any comment or argument.

When it comes to deciding on the engine best suited to a power plant the engineer is confronted with a multiplicity of designs to select from. The distinct types, however, are not so numerous, and having settled upon the type best suited to the work in hand, the matter of selection becomes comparatively easy. This solution of this question will depend on the size of the engine required, the class of service and the degree of economy aimed at. 'In manufacturing establishments, where the machinery is all driven from a line shaft, and using one hundred and fifty H. P. and above, if a high or medium degree of economy is desired, engines of the Corliss and kindred types

are generally given the preference. When the cost of fuel is high, and the other conditions are such that a high degree of economy is desirable, then the engineer is warranted in advising compound or triple engines, and to be operated condensing if there is a possibility of obtaining water for condensing purposes without too great a cost.

There are many places and classes of service for which the high speed automatic engines are so admirably adapted that they are always given the preference, in fact these two types of engines can hardly be said to be competitors, the field of each being so entirely distinct from that of the other. The discriminating perception of the experienced engineer is the best, however, to decide on which is best adapted for any particular service, and from which may be expected the best results, all things considered. We have seen the vertical engine take a prominent place in our large electric lighting and street railway power plants during the past few years, and I believe it will be received with an increasing favor by the owners and engineers of our manufacturing concerns, as its evident superiority over the horizontal engine becomes better known.

Of the minor details of a steam plant, I shall not attempt to speak. The competent engineer will select them so as to be in keeping with the balance of the plant, and with the view of their general excellence in construction and operation.

From what has been written it is apparent that the engineer called upon to design a steam plant must study well the surroundings and conditions under which it is to operate, and exercise a discriminating judgment as to what it best suited to the work. In one case the most efficient plant obtainable at a high first cost would be the best, in view of its greater economy of fuel consumption in operation, while in another case when the fuel is a refuse of the product of the establishment its cost becomes of less importance, and the first cost of the plant is the governing factor in its design. It follows, then, that the strictly modern steam plant is not necessarily made up of the highest grade machinery or even the most economical in fuel consumption, but is the one, everything considered, the best adapted to the requirements of the work it has to do.

The plain side valve engine is as pre-eminently correct in its place of driving a saw-mill as is its more aristocratic brother, the vertical compound condensing engine, in operating a direct connected electric generator.

MR. HUBBELL: I would like to inquire how he represents the draught of the chimney?

MR. PARKS: There is a draught gauge used generally, a "U" shaped tube of glass; one side is connected to the stack, and the other side is exposed to the atmospheric pressure. The difference in height of the volume of water will represent the gauge pressure, or rather the draft pressure.

MR. HUBBELL: After the fire is burning?

MR. PARKS: Yes, sir.

MR. HUBBELL: What would be a fair draft pressure?

MR. PARKS: About a half inch; that is, it will run from .33 to even an inch in extraordinary strong draft.

MR. HUBBELL: Would you think an inch and a quarter too much?

MR. PARKS: Well, it is pretty strong draft, pretty near a forced draft.

MR. HUBBELL: Our company erected a large addition to their plant and they put up a stack eight feet in diameter, one hundred and thirty feet high, and when we tested it by the glass "U" gauge we had an inch and a quarter draft pressure.

MR. PARKS: Well, there is no real objection to it, only you have got to control that draft by proper dampers.

PROF. WEIL: Would not that depend on the kind of fuel used?

MR. PARKS: Yes. For certain sizes wood would do, and I should want a little anthracite coal for certain other sizes.

MR. SEARS: How long are those grates supposed to last?

MR. PARKS: That is a question that is very difficult to answer definitely. I have known them to burn out in a few hours, and I have known them to last for eight or ten years; it all depends upon the care they get.

MR. SEARS: We put one in our pump house and it burned

out within one hour; there was one put in last September, and it has not burned out in three months.

MR. PARKS: I know a case of that kind where they were burned out in an hour by getting them clogged up so they could not shake them; but that is generally due to improper management.

MR. TODD: I have had some little experience in a very small way. I left our distillery with some men and went to supper one evening, and when I came back we had no grates left. The whole thing dropped out of the bottom, and I found the trouble to be that they had allowed the ashes to accumulate close under the grates so the air could not get under, and it just melted the grates; and in other instances I have noticed they burn out very quickly that way. I know in three years that a little distillery I have in my place, by being very careful, you can scarcely see that the grates are burned at all. I am very careful to keep a large air space under them; there is a space there of eighteen inches which I always keep as clean as possible, and I have no trouble with the grates.

PROF. PASHBY: The fuel you used, was it coal?

MR. TODD: No, sir; it was wood.

MR. SEARS: What kind of a distillery was that?

MR. TODD: A peppermint distillery.

THE PRESIDENT: Mr. Parks, which do you regard as the fairer way of determining the duty of a pumping engine, the duty test conducted at the highest rate of speed the engine is rated at, or half speed?

MR. PARKS: I wouldn't consider it fair to conduct a duty test at the highest speed the engine was capable of running because it is very seldom that a pump or any other machine is capable of maintaining this high rate of speed for any great length of time. I should consider the mean speed to be the right speed for determining the duty, particularly in favor of the buyers.

THE PRESIDENT: Suppose a pump is made by a manufacturer who guarantees a duty that is seemingly a little high, the construction is good, the work has been honest, and the test—whatever that may be—say at half speed, falls somewhat

below the duty for which the machine was contracted to perform. What is a fair way of making an adjustment between the purchaser and the manufacturer; make him take that out and put in an engine which comes up to that recommendation, or make some adjustment on the line of the difference in fuel that would be consumed for a given time, estimating this difference in the duty performed?

MR. PARKS: I have heard of cases that were adjusted on the line that you speak of, that is a reduction in the price paid for the engine which would represent the actual difference in fuel for the same for say ten years' time, which would seem to be as fair a way of making an adjustment as could be arrived at, perhaps a great deal more so than the rather extraordinary way of taking the machinery out entirely.

PROF. WEIL: Of course the manufacturer will want to give you as great a capacity as possible for a given sum, and that question of capacity is the all important thing to the purchaser, and I am certain that when a test is run on a pumping machine, the engine should be run to "capacity," because you are very much interested in the question of capacity and whether the engine has capacity enough, and it is not probable that a well made engine will show a capacity less than that guaranteed. But there may be mechanical defects, and if you run a pump at the highest rate of speed for twenty-four hours they may show.

SOME COMPARATIVE TESTS OF AMERICAN AND IMPORTED PORTLAND CEMENTS.

F. F. ROGERS.

Early last spring a representative of a large American Portland cement industry visited our city with a view of getting us to introduce his cement. As the cement we were, and still are using for concrete walks, is exceedingly satisfactory, I was inclined to be a little short, and informed him that we "knew a good thing when we had it and would let well enough alone." He referred to some excellent work which had been done with this cement. Among them was the concrete work in and around the new postoffice building in Detroit. Still I paid little heed, and though a barrel of this cement was shipped to the town, it remained untested for several months. This was the Alpha cement. In August of last year it was my good fortune to visit Milwaukee and look over its public work. Here I saw the new Plankinton building, with its five floors and roof, 105,000 square feet, all made from Yankton Portland cement, under the Ransome patent for concrete and twisted iron construction. W. A. Monsted & Co., of Milwaukee, were the contractors. I concluded that there was some good American Portland cements, and went home fully resolved to give some of them a test. Accordingly letters were sent to about a dozen American manufacturers of Portland cements asking for samples of their products. Most of them promptly responded, and the following table shows the results of these tests, together with tests of such imported cements as I could get samples of in the city. The tests were not made under the specifications adopted by the American Society of Civil Engineers, but were all made by one person, and the tests are comparatively uniform. Great pains were taken to give all the cement the same treatment, and while the tests may not be of much value for comparison with other tests, they show the

relative value of the samples tested. If some of the samples sent for testing are better than the average output of these mills, they at least show what can be done with these cements, assuming that all dealers were honest enough to send cements of their own manufacture. An examination of the table will show that there are some excellent American Portland cements:

TABLE.

Brand.	Breaking strength in pounds.				Remarks.
	24 hrs.	7 days.	28 days.	56 days.	
Globe	92	218	347	403	From stock.
	102	248	347	445	
Brooks, Shoobridge & Co.	228	434	603	656	From stock.
	235	434	612	685	
Germania	235	537	675	710	From stock.
	208	560	643	750	
Owen Sound	132	428	463	515	From stock.
	145	468	457	----------	
Diamond	115	300	315	425	From stock.
	108	303	360	434	
Alpha	190	566	609	740	From stock.
	215	603	740	828	
Chicago	118	491	553	653	Sample.
	118	434	569	688	
Buckeye	60	360	418	511	Sample.
	80	303	518	591	
Yankton	----------	391	634	681	Sample.
	168	453	618	622	
Saylors	----------	391	615	830	Sample.
	----------	497	522	720	
Atlas	198	653	766	856	Sample.
	232	734	743	978	
Giant	158	422	591	----------	Sample.
	188	366	637	685	
Egypt	202	340	363	400	Sample.
	238	372	372	360	
Vulcanite	165	734	670	803	Sample.
	165	734	831	909	
Sandusky	162	694	903	858	Sample.
	175	715	953	----------	

MR. SEARS: Why didn't you put on the cost of each of these cements delivered at your place?

A. I only received the price from two or three of the con-

cerns, and for that reason I wasn't able to make a fair comparison. There are a great many factories, etc., built entirely of American Portland cement, and I am candidly of the opinion that in a few years we shall be importing but very little cement.

PROF. PASHBY: How were the briquets treated after the moulding?

MR. ROGERS: They were allowed to stand in air until they were set and immersed in water till the time of testing.

PROF. PASHBY: The setting in air required how many hours?

MR. ROGERS: Probably five or six or seven hours before immersion. They were allowed to set in that until they were set so they would immediately come out of the moulds.

MR. RIGGS: At the Maumee river bridge at Toledo they used the Sandusky Portland cement. It was tested and the city engineer's office has a very complete record of this cement, and they hold it in high esteem. I had a little experience at Pontiac this summer in the construction of a system of sewers, where we encountered a large amount of ground water. The cement which we used was Milwaukee, and wholly inadequate on account of the ground water. I started a number of tests to find a quick setting cement, the difficulty being that it was impossible to keep the water away from our work in the sewers longer than fifteen to twenty-five minutes. My attention was directed to a cement manufactured in Lisbon, Ohio, the Lisbon hydraulic cement, which was said to be very good, and I sent for five barrels. We found that mixing up a barrel of it and leaving it exposed to the air for three minutes and then immersing it in water it didn't disintegrate and settle down, as all of the other cements did, but held its shape and would set under water so that in the course of one or two hours it was quite hard. In the air it would set altogether too quickly; but we tried a mixture which met our requirements on the sewer work and kept out the water. I never heard of the cement before, and have never seen it advertised, but only heard of it through a friend of mine. We used about five hundred barrels of it at Pontiac, and found that it run about as

well as the sample, and where quick setting cement is required I don't think you can find anything better. I made one seven day test, and if I remember right it ran about 135 for one day, and about 225 for seven days.

MR. SEARS: We want a cheap cement that is good. Three or four years ago I wished to economize and sent for a sample of cement which I tested, and after a fair trial of it I wrote the manufacturers I would not take it as a gift. I didn't know but I had made a mistake; but Mr. Rogers' table indicates I was not far out of the way. The manufacturers wrote me that that was some material that had been exposed during the winter and not a fair sample. At the World's Fair I saw quite a display of their work, and they received some premiums at that fair, and I was one of the first men to receive one of their circulars, showing the value of their cement. I then wrote and asked for another sample for testing, but they never sent it to me.

MR. RIGGS: They had quite an elaborate display of their cement at the Cleveland meeting of the society four years ago.

MR. ROGERS: I would say in regard to this Buckeye Portland cement that the first test showed very low for twenty-four hours, and thinking that perhaps that was not a fair average, we mixed up some more and made another test which showed practically the same thing; so I am satisfied that what is shown here is a fair average of the cement sent us.

MR. SEARS: I don't want to run down any man's business; but I decided not to use it.

THE PRESIDENT: I used a brand called "Solomon's" Portland cement two years ago. I had no opportunity of making any test, but the cement worked very well and was quite a reasonable priced cement; we gave $2.25 a barrel for it.

MR. SEARS: A good cement?

THE PRESIDENT: Yes, sir. The next year we wanted to use some and I sent down an order and couldn't get it; they claimed they couldn't give it to me for some two or three months, longer than I could wait. Somebody else had found it was good, I think.

HOME MADE CEMENT TESTING MACHINE.

About two years ago the rapidly increasing use of cement in our city made me very anxious to procure some kind of testing machine. It would have been folly for me ask the council for $100 to purchase a good machine with, and I began to look about to see what could be done. The means at my disposal being small I asked the council to allow me $15 with which to build a cement testing machine. It was allowed and I began with the machine described in Prof. Baker's "Masonry Construction" for a model.

Among the things I could not well make were the grips, but I resolved to have good ones, and wrote Reihle Bros.' Testing Machine Co., of Philadelphia, for a pair of "W. R. C." cement grips. They came promptly, so did the bill for $12. That nearly broke my heart, but as the grips were the best to be had, I resolved to go ahead, and the bills were paid, leaving me $3 with which to build the whole machine.

As I was following the model above mentioned, the first machine was much as you see in the photograph, with the bed piece omitted, and a lever arm to correspond in length with that part of the machine above the present base. The power was to be applied by rolling a weight out upon the lever arm by means of a grooved pulley. The present counter weight was therefore attached to a grooved pulley and rolled out on the lever arm over a half round maple track nailed to its upper surface. This I found developed a strain of less than 200 pounds, but as I was then only going to make short time tests of American natural cements, that was ample. The lever arm was graduated each five pounds by attaching a large scale to its short arm and marking the points passed on the long arm for each additional five pounds of weight. The machine was put in use, but was very crude, the most serious objection being

that it was almost impossible to move the weight without jarring the machine, and of course jars were very objectionable as the breaking point was approached.

The bearing was made reasonably sensitive, by using a bolt made from an old three cornered file, by welding the head and screw ends of an ordinary bolt to the file. The file was prevented from turning in its bearings by screwing up the nut so tightly that both nut and head sank into the wood. The bearing in the lever arm was protected by inserting a piece of tempered half-inch gas pipe, cut same length as thickness of lever.

The upper grip is attached to the lever arm by means of a wrought iron clevis and bolt, which supports a longer wrought iron hoop terminating in a threaded rod at top, which screws into the bottom of clevis, thus making a swivel capable of adjustment. The upper grip is carried in this loop and is given a pivot bearing by means of a hardened cone projecting from the yoke of the grip, which works in a small depression made for its reception in the loop. The lower grip is attached by means of a strap iron loop which passes though the yoke of the grip and is bolted to base of machine. It has a similar cone bearing to the upper grip. Thus the grips instantly adjust themselves when pressure is applied, giving a strain along the transverse axis of the briquette which nearly always results in a square break.

The machine was now quite satisfactory aside from its capacity and the means of applying the power. These I remedied as follows. A new lever arm was made 7 35-100 feet long with the fulcrum placed one foot from the grips. (It would have been better with a more powerful ratio.) A galvanized iron bucket with heavy bail, protected around the rim with strap iron, was supported at the long end of the lever by means of a wrought iron hook. A cylindrical hopper filled with dry lake shore sand is supported near the bucket and just high enough so that a stream of sand can be drawn into the bucket by means of a small slide at bottom of hopper. The briquette being adjusted, the stream of sand is started, thus applying the pressure at a uniform rate and without a

jar. After breaking, the bucket of sand is weighed and the strain noted, by referring to a prepared strain sheet tacked upon the wall near at hand.

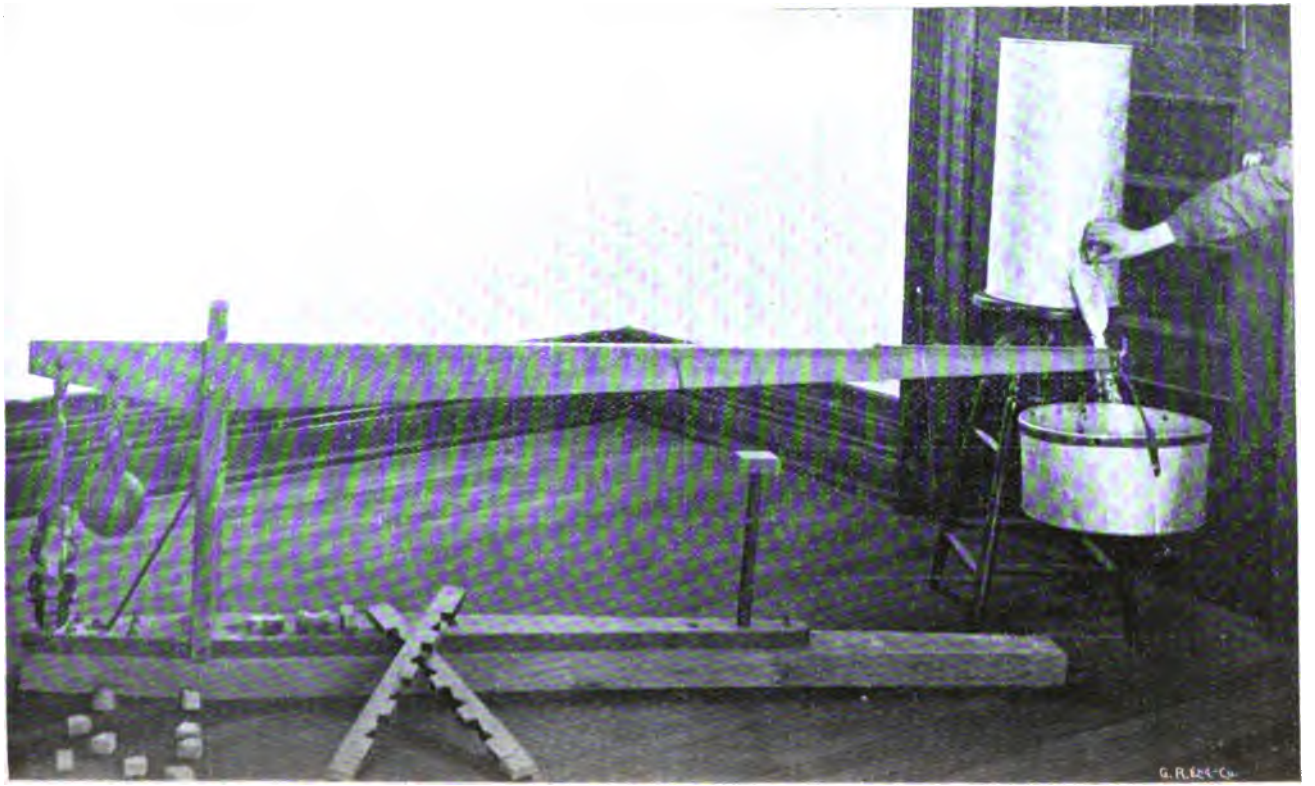
The theoretical strain is not used, as friction is still quite a factor. The machine was tested by raising it from the floor and attaching a platform to the clevis on short end of lever. This platform was loaded for different weights up to 800 pounds and the weight of sand required to balance the machine at each successive trial was noted, and the strain sheet referred to thus prepared. I might say that for breaks of over 650 pounds we have to use some heavy weights along with the sand.

The moulds first used were of wood, but these were very unsatisfactory, as after they had been a short time in use it was almost impossible to get the briquettes out whole, and the moulds had to be well soaked before using so that they would not absorb all the water from the briquettes.

We now have some wood moulds, copper lined, four moulds in a gang. These are held together with ordinary iron clamps. We have found it a good practice to place a piece of oiled paper on the glass under the moulds. I would advise buying good metal moulds if possible.

This completes the outfit, and it can be made for less than $20, including the high priced grips, if one knows what is wanted when he starts. It is needless to say that this one cost more. The machine is somewhat clumsy, and requires considerable space, but can be operated by one person quite rapidly, and the strain determined with practical accuracy. It seems to be a good substitute for a higher priced machine where the funds cannot be had to purchase one.

THE PRESIDENT: You have this paper before you for discussion. It has always occurred to me that it was short sighted economy in municipal corporations to go ahead year after year buying cement, either directly or through contractors, without knowing what the qualities of it were. So far as I know, there are very few towns that attempt using a physical laboratory for making tests for any, or of a general character. A good many places have these testing machines,



and anything in this paper showing how a testing machine can be secured by city engineers and special engineers is of real practical value.

MR. SEARS: I want to commend Mr. Rogers for his ingenuity and liberality; and I hope that the corporation that employs him will appreciate his devotion, because it is certainly a great protection. I wish we had more men like him throughout the country, and I think we would have a little less stealing.

THE PRESIDENT: Is there anything further to be said in discussing this machine?

MR. ROGERS: The machine was adjusted for actual tests by weight, but of course there is more or less friction in the machine, and of course with the bar the length that it is,—the fulcrum being one foot from the shorter end and 6.35 from the other, we would expect a ratio of 6.35 to one, and it was very nearly that. But in the first test of the machine we tested it up to 150 pounds by using a heavy scale on the short end of the lever and testing it each ten pounds, and we found we ran very uniformly up as far as we wanted—uniform ratio—and we thought it was safe to pro rate it, and we placed it quite high; but we began the test of some American Portland cement,—of which I will show you something later—and some of the breaks ran up to between 900 and 1,000 pounds; but these were run too high and so much above the ordinary published tables that we began to be suspicious of our machine, and we raised it up and put a heavy platform on it and began at 200 pounds and loaded it up each 100 pounds to 800, and we found a small percentage of errors, but it wasn't very large, and we corrected our books to correspond with it. But I have some tables showing the breaks of some Portland cements with some other cements that we have broken which show remarkably high tests in American Portland cements, and they are accurate. I might say right here that during the summer we have tested all the cement that was used in the Petrolia system of water works that was put in over in Ontario. The engineer was Mr. Willis Chipman of Toronto, and he began his work there and was getting his cement tested at the School

of Practical Science, but they were so slow he came over to us and we tested all the cement that went into their work.

MR. SKEELS: How did these tests of the different quantities that you received average; what was the quality of each as regards the quality of the whole cement?

MR. ROGERS: Well, some of them were very uniform; there was only one inferior lot of cement sent over to us in the whole lot that we had; the others ran very uniform. Mr. Chipman expected a break of about an average of 125 pounds in 24 hours, and they ran from 105 up to 150 in 24 hours, and almost in every case it showed a good increase with the length of time. You can study that more fully in the tables. I might say, however, that our clamps sometimes spring a little and sometimes we found it necessary to dress the briquettes a little before breaking; but we kept a tool for that purpose and carefully dressed the briquette to an inch section each time before it was broken.

MR. APPLETON: What did you use for briquette moulds?

MR. ROGERS: They were simply wood moulds cut in the form of the briquette and lined with copper.

MR. APPLETON: I had some made of very heavy iron; I think they cost me $1.50 each. Of course if you are going to test one cement against another it is very essential that every briquette mould should be alike.

MR. ROGERS: Certainly it would not do to have different sizes. I am not altogether satisfied with the moulds we were using, but they were the best we could get at small expense. The wooden moulds could be used if they were thoroughly soaked before using so that the mould would not draw the water from the cement. After they become old it is almost impossible to get the briquette out without breaking.

MR. APPLETON: You can screw the sides together and then of course loosen the screws and that lets the briquette right out, and that easily without straining it. Of course it is quite essential that the briquette should be left just as the cement dries.

THE PRESIDENT: When you break a briquette do you have to compute the strain each time?

MR. ROGERS: Our table is carried out so that there is no computation at all; it is carried out so small we have the strain for each five pounds, and you can readily take it from the tables as quick as you can write it down.

THE PRESIDENT: I wonder if a scale could not be graduated and put on a spring so that the water in your bucket would show the strain.

MR. ROGERS: It could be done, and we thought of it; but we would have to set the machine so high that we discarded that. Where you have a weight of say a hundred pounds the fall of your bar striking on the block would vary your scale.

MR. APPLETON: Don't you think that the greatest difficulty in testing your cement is in the moistening of it. I have tested cement for my own information, and I have worked very patiently at it. Now I have noticed that with the same cement and the same briquette moulds, in fact everything about it the same, if you make your cement at one time a little wetter or a little drier, it will not give the same result. If you were testing one man's cement against another for a fair test, it might be a disadvantage to get one a little wetter than another.

MR. ROGERS: I think Mr. Appleton is entirely correct in this. You will perhaps remember a report in the Engineering News a few years ago—I have forgotten who made the test—and about ten different cements were mixed together so as not to give any one cement the advantage over another, and this mixed product was sent out to half a dozen or so laboratories at colleges, and the highest test of the same production was three times the lowest test.

MR. APPLETON: All the same cement?

MR. ROGERS: All the same cement, the same thing. In the work we have done the cements have all been mixed by one person and great care has been taken to mix them with the least possible amount of water. The water has not been measured in some cases; we have become so skillful the variations are quite small.

MR. SEARS: I suppose the person is not interested and does not know the dealer and has no interest at stake?

MR. ROGERS: No, sir; he has no interest at stake. He is my assistant, and I would trust him as far as I would myself.

PROF. PASHBY: I ask if there is any patent on those clamps?

MR. ROGERS: There is no patent and none intended.

PROF. PASHBY: On the grips is there?

MR. ROGERS: Yes, I suppose there is.

MR. APPLETON: These moulds you spoke of, I can't see anything to cost $12.

MR. ROGERS: There is nothing about them; but if you write to Libbey Brothers for a set of cement moulds you will find they cost you about the same.

MR. APPLETON: They will come in brass, will they?

MR. ROGERS: You can get either brass or iron.

PROF. PASHBY: Have you found it necessary to put any paper or rubber in between the cement and the grips to obtain good results?

MR. ROGERS: Well, these grips,—there is a bolt on the edge of each grip, and there is a rubber cylinder on this bolt which protects the cement from the grip; we also have brass cylinders, but all the tests have been made with rubber cylinders on the grips. They wear out quite rapidly, and I found out after they were gone I could take rubber tubing and cut new ones just as well as to buy them.

SOME DETAILS OF SEWER CONSTRUCTION.

GEO. M. AMES.

To the Michigan Engineering Society:

GENTLEMEN—The drawings herewith presented show some of the details of recent sewer construction in this city.

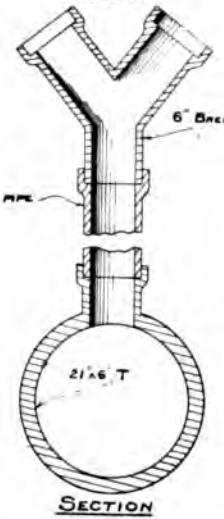
Fig. 1 is a profile of a sewer through a hill where the maximum cut was about 28 feet; the standpipes show the general location of house connections, and Fig. 2 shows the same connections in detail for purposes of record; the distance of each is measured from the manholes. In the hill illustrated the material was clay, and was not thoroughly rammed when replaced in the trench, and of course settled considerably. The load thus brought upon the top of the forked connections was too great for the main pipe to stand, and several of them were broken down and had to be removed.

It was found that the pipe adjoining the T into which the spigot of the T projected was also split. Fig. 3 is presented as a suggestion to overcome the tendency to crush the main pipe in case of settlement of the filling.

Fig. 4 shows the general form of manholes constructed during the past year. The ordinary manhole, 3 x 4 ft. inside is too small in which to work to advantage, while the size shown is ample and the difference in cost is insignificent.

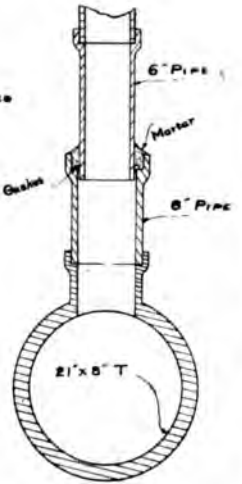
The design for catch-basin, Fig. 6, is one that has been constructed during the past two pears, and is the most satisfactory of anything tried in our city. The cast iron cover cost during the past season from $5 to $6; the curb stone, 3ft. 6 in. long, in position, from $4 to $5. For our steep grades the waterway into the basin is ample and not easily clogged. The basin being in the roadway there is no use for littering the lawn while cleaning the basin, and the neck of the basin is

Fig. 2.



Section

Fig. 3.



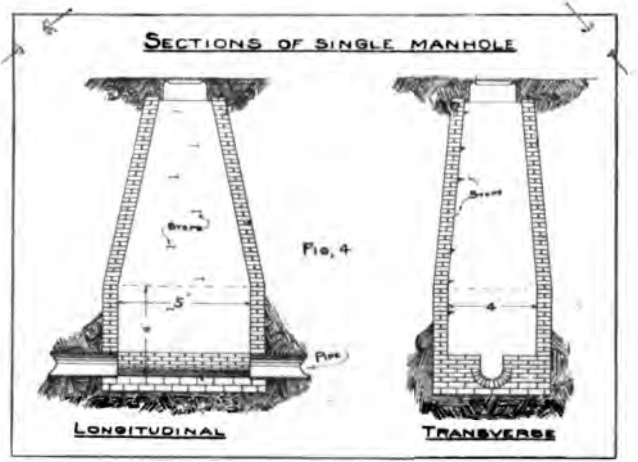
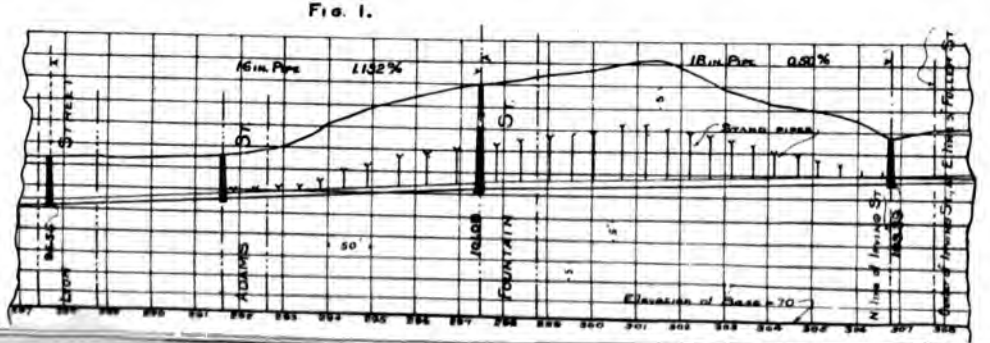


Fig. 4

Fig. 1.



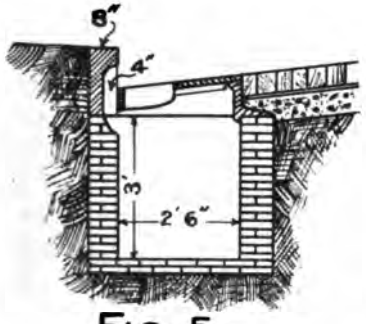


FIG. 5.

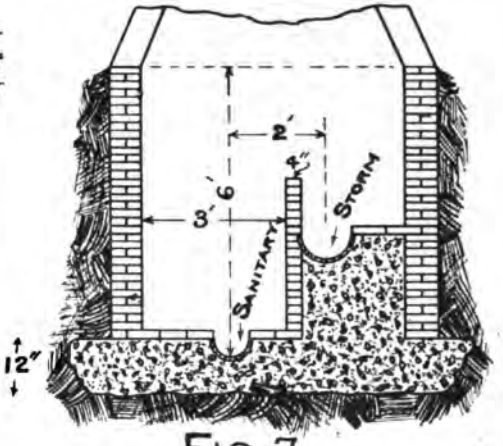


FIG. 7.

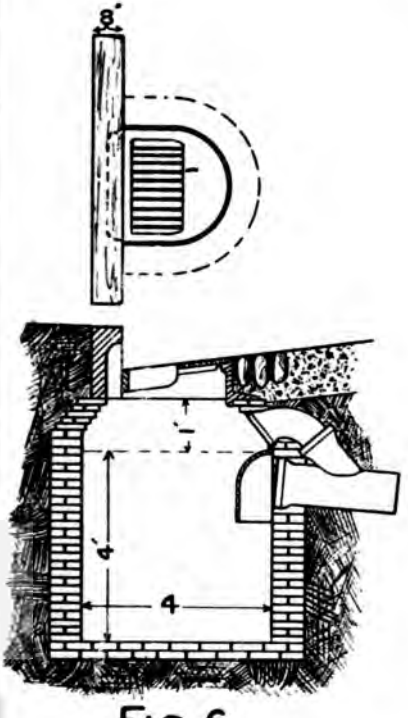


FIG. 6.

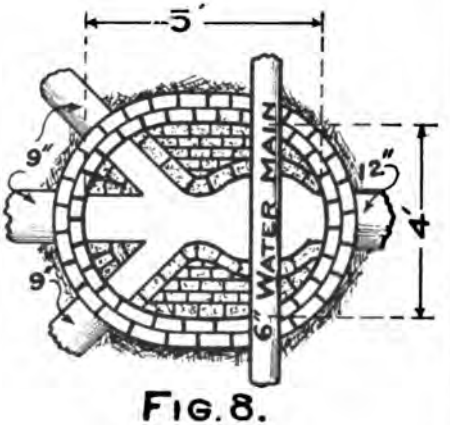


FIG. 8.

Fig. 5 shows how the same cover is often used over small intake chambers on paved streets, or where the amount of water to be caught is small.

Fig. 8 shows the plan of a manhole placed at the point of crossing of the water main, only a few inches above the grade of the sewer, the chief merit being that stoppages at that point could be easily removed.

Fig. 7 shows how manholes have been made where storm water and sanitary sewers have been laid in the same trench. Ventilation through the storm sewer and catch-basins is thus secured for the sanitary system, and the cost is less than for independent manholes for each system.

thereby made short, while the opening, when the grate is removed, is large.

PAINTING A BLOCK WITH AN AIR BRUSH.

J. J. HUBBELL.

The Buckley and Douglas Lumber Company's salt block erected at Manistee in 1896 is a block of generous dimensions. The main building is four hundred and seventy-five feet long by three hundred and fifty-six feet wide. This building contains twelve grainers, each twelve feet wide by one hundred and fifty feet long; six settlers, each twelve feet wide by eight feet deep and one hundred and seventy-eight feet long, and sufficient storage space to hold 300,000 barrels of bulk salt. The vacuum pan block is fifty by fifty-six feet and sixty feet high, and contains two vacuum pans eleven feet in diameter. The cisterns are two hundred and eight feet long by forty-eight feet wide, and over fifty feet high. The four wells, 2,000 feet deep, from which the brine is pumped, have each a tower twenty-two feet square at base and ninety feet high, with a building annexed to each sixteen by fifty-four feet. The barrel factory is eighty-four feet wide by one hundred and eighty-four feet long. The storage warehouse for barreled salt is seventy-five feet wide by three hundred and fifty feet long. The steam is generated in seventeen large boilers located in a separate building attached to the sawmill of the same company. The steam is conveyed to vacuum pans and salt block by one sixteen-inch and two ten-inch pipes, while the barrel factory is run by an electric motor, the current being generated at engine house. The capacity of this block is 2,400 barrels per day, one-half fine or vacuum salt and one-half coarse or grainer salt; but I did not intend to enter into a description of the block, but rather to speak of a job of painting with an air brush.

Late in the fall I was requested to take steps toward the painting of the block. About the only instructions I received were that they wanted a good job done as cheap as possible,

and that they wanted it red. The buildings to be painted did not include the boiler house, that was of brick; or the barrel factory, which was iron clad with corrugated iron, but the other buildings, which covered about five acres of ground and whose surface was estimated at fully 1,000 squares. These buildings had been sided up with rough hemlock lumber and battened with rough, square cornered, three and four inch battens, as it was not originally intended that they should be painted. The problem was, what kind of paint and how to put it on? I investigated several kinds of outside everlasting whitewash, composed of lime, rice, glue, salt, etc., also cold water paints of alabastine, whiting, etc., and other cheap mixtures that were part lead and oil, but found nothing I considered good for the purpose. A lead paint was objectionable on account of cost and because of the fumes of sulphur which come from the wells. I also found that linseed oil was very cheap, only twenty-five cents per gallon for good raw oil, and that I could get red oxide of iron ground in pure linseed oil and thinned with benzine at a price that, considering the quality, was cheaper than whitewash. That settled it. We took the oil paint and ordered six hundred gallons, that being the least quantity estimated as required. The question of paint having been disposed of, it remained to be settled how to put it on.

Three bids were received from local painters to put it on by hand, one at thirty-five cents per square, the painter to furnish his own brushes and ladders; one at twenty-eight cents per square, the company to furnish brushes and ladders, and one at $300 for the job, the company to furnish everything but labor. Any one of these bids was reasonable, but all the painters thought that a good job could not be done with a single coat, and that it was too late in the season to undertake it. I then made inquiries in regard to the air brush. I knew that the World's Fair buildings were whitewashed with an air brush, but could not find by inquiry or advertisements that any one was engaged in the manufacture of the brush. I learned of several whitewash air brushes, also that the Peninsular Car Works, of Detroit, were using one, presumably to

paint cars. I visited their works and found that they had one which they had used to whitewash the interior of some of their shops, but had never attempted to use it to apply oil paint. They kindly loaned me the design of their brush, which I had traced, and from this plan had one manufactured at our own shops. The brush itself only cost about $10, and with one hundred and fifty feet of best quality of three-quarter inch hose, less than $30. We took an air pump from a locomotive, cylinder eight by eight inches, and set it up in one of the drill houses, where easy connections could be made with steam line. An air reservoir, one discarded from a locomotive, of a capacity of about ten cubic feet, was placed beside the block and connected with air pump by one-half inch gas pipe, it being intended to move air reservoir from time to time as the work progressed. One hundred and twenty-five feet of the hose was used to connect the brush with the air reservoir and twenty-five feet to connect the brush with paint bucket. Two portable stagings, one twelve feet high and one eighteen feet high, were made. These stagings were easily moved along the sides of the block and enabled the operator to stand about four feet from the face of the building, while the one hundred and twenty-five feet of hose permitted painting for that distance in all directions from the air reservoir. The apparatus was now ready for use.

The paint came in barrels of fifty gallons or more each. To mix the paint an iron flange with a short journal was screwed on the center of each head of a barrel. The barrel hung upon these journals and by a crank revolved like a grind stone until the paint was thoroughly mixed, then two or three gallons were drawn off at a time, as was needed, by a molasses gate set in the side of the barrel; by this means the paint was kept of an even consistency until the entire barrel had been used. The paint bucket being filled, the air pump started, the operator was ready for work. The pressure of the air in the reservoir was probably from forty to fifty pounds, and as the air passed through the stem of the brush and discharged it threw the paint from the bucket and discharged it with the air, not as a stream nor even as drops of paint, but as fine as a mist.

It resembled a discharge of red steam. The discharge was controlled by a valve in the stem of the brush. The operator soon learned to handle the brush, and could paint from eight to ten feet above his head and to the same distance below his feet, painting the upper portions of the building from the stagings and the lower parts from the ground. It required two men, one to mix the paint and keep the bucket filled and one to handle the brush. The air pump worked automatic. It was found that the brush put the paint on very even and blew it into every crack and crevice, and covered the rough surfaces much better than it could be done by hand. There was little waste of paint. One gallon of paint would cover about one and one-half squares of surface. Two men could paint about fifty squares in a day, while five squares is considered a good day's work for one man by hand. When one section of the building had been painted the air reservoir was moved along two or three hundred feet and the one-half inch pipe connections from the pump extended. Before finishing the work the air reservoir was over 1,200 feet from the pump. The operator could put on the paint of any thickness from the faintest blush to a heavy coating. The windows were protected by light, movable frames, covered with canvas. The air reservoir near the brush I consider a very important feature of the machine, as the painter frequently stopped to change his position, which enabled the air pressure to come up to maximum; if it had become reduced there was a condensation of water in the air pipe, and as the weather was cold, provision had to be made to drain it off when the pump stopped over night or for any length of time, to prevent it settling in low places and freezing. It was found best to keep the paint bucket as high, or a little above the nozzle of the brush. The suction of the brush would lift the paint fifteen or twenty feet from the bucket, but it took time after the air valve was opened before the paint would begin to discharge. When the bucket was as high or higher than the brush there was no delay. It was found necessary, however, to put a small stop cock in the paint hose next to the brush to prevent the paint from flowing from the nozzle when not being used.

As to the cost, it was found that oil paint could be applied to large buildings at a cost not to exceed ten cents per square, and that the cost of painting the block did not exceed fifteen cents per square, including all labor of shop men in placing and a reasonable sum for use of air pump, pipe, reservoir, and brush, or less than one-half of what it would have cost to have had the work done by hand.

MR. HUBBELL: Here are two samples of the work done; you can see it just as the brush put it on.

THE PRESIDENT: Did you find any difference in the amount of paint it took to cover a planed and a rough surface?

MR. HUBBELL: We didn't have sufficient planed surface to tell that, and we kept no track of the amount of paint. Naturally it would take a little more paint to thoroughly cover a rough surface, that is to make a satisfactory covering.

THE PRESIDENT: There is an air brush used by portrait artists and other artists which it occurs to me would be a very useful instrument in any drafting room.

MR. HUBBELL: I might say that the half-inch pipe from the air pump to the reservoir was a small pipe. We ought to have used three-quarter inch pipe; but we had a large quantity of half-inch, and it answered the purpose for the reason that the reservoir at the end of the small pipe empties an accumulation of air as the brush is started. Without the reservoir I should doubt the advisability of using so small a pipe as that to convey the air to the pump in a great distance. (Illustrates brush on board.)

THE PRESIDENT: The air brush that artists use is on the same principle. They have a little cup at one side and the air current goes through and sprays it.

DRAINAGE SPECIAL ASSESSMENTS.

E. STRONG, KALAMAZOO.

A drain tax is a peculiar one. The roll is known by title as "Drain Special Assessment Roll."

It is provided for by statute and hence is just as legal as a supervisors' tax, and for the same reason. If the drain commissioner has once secured jurisdiction, it is no more difficult to make a legal roll than to make the same amount of supervisors' roll. But this little *if* is a bad one, and has brought woes unnumbered to the drain business in past years. And let us not imagine the present drain law a daisy, and only a daisy. It is young, to be sure. So is that early blooming flower of spring, that rose of the swamp called cabbage. Young as this drain law is, the petition itself is filled with minute specifications. Fatal? Yes, they *are* fatal. It requires in the first place three or more to sign the petition who are crossed by the drain. Hence no legal drain can be laid in Michigan that crosses only two men. If the drain crosses three, one can sell to the others and stop the work. No drain commissioner that I have seen takes this view of it. But the words of this new drain law stand up plain as the sun at noon. The Department of State ignores this language in its form of petition sent out in its law pamphlet to commissioners. It sagely says, in other words, that three or more of the signers should be subject to a *tax* for the drain. But who said that? Not the statute. It also ignores the fact that this young law also requires 30 per cent of the signers to be crossed by the drain. Hence if the drain crosses four men and there are fifteen signers you must erase two names, or you fall short of jurisdiction, and *then* when you come into court you are likely to find one lot in his wife's name, or some other name, or that his son signed the petition for him.

These defects would be of minor importance if they did not

relate to the petition itself and the jurisdiction. No act of the commisioner can be a legal one if the application is defective. It must comply with every statutory requirement, reasonable or unreasonable. Common law is supposed to be founded on reason and common sense, but statutory law is sometimes lacking in both, and the drain law is statutory law. Errors committed *after* the petition in the subsequent work, clerical errors, errors in the survey, errors of judgment in the tax, can be cured and the kind hearted court will allow the commissioner to correct them. But the errors that lie in the petition are incurable, because the commissioner fails to get jurisdiction in the case. Therefore sound advice indicates that the first thing to be done in making a *drain assessment* is to give the petition itself a careful study, and if possible correct it even at this late day, for no drain tax will fail in Michigan of final collection if the commissioner understands his business, and his business is to get up and begin anew every time he is knocked out, even in court. And he begins anew where the error was made. The new drain law has settled *this* point.

I remember seeing a commissioner defeated in court under the old law, and after an adverse decision, he asked the court where beginning "anew" meant in that case. His Honor said, "Right where you made the error." The very next day the successful parties came and said they were ready to settle and to take up with the commissioner's first proposition. Even the successful party in court can see that it is the plain duty of the defeated drain commissioner to resign, or get up, with some one *else's* blood in his eye and begin again.

But we will suppose the early litigation passed—the releases signed—the first published notice out and a copy served on each person liable to tax. This gives him personal notice, which is necessary, and in this notice are the minutes of the survey and the descriptions of *all* the persons taxed and the time of review. These requirements make a very long and expensive add., and at first you will think it ill-advised. However, after giving it a trial I have changed my mind. Every man interested in the drain tax wants to know who is going to pay for

it; location, dimensions, length and fall, day of letting and review. I never knew but one man to avail himself of review.

Now it becomes necessary without delay to prepare the *apportionment* and have it READY on the day of letting. If this cannot be ready at that time, announce at the sale that the apportionment will be subject to review ten days longer more or less. This will also extend the time of appeal the same amount.

The survey, the profile and map, have already been made, and on the map the descriptions of the assessments have been written. With a blue pencil proceed to carefully mark out the irregular borders of the drainage district. *This* is important, so that in after years you can take your own map and at a glance see just what you did when all the details were fresh in mind. I have seen the *want* of this in old maps. And how much more is this true when others make the assessments. This blue line should not be omitted from a drain map. If the *surveyor* has not made the examination the *commissioner* should put on this border. The law seems to require the commissioner to make a determination of the drain district, and this is the most obvious way. Each piece of land should show the acres, and may show also the acres of wet land if determined by survey, by estimation, or the evidence of other persons. Usually the owners know almost exactly the wet land.

The commissioner can keep constantly with him a note book for this purpose and prepare and make out a list at his first examination and afterward criticise and revise. If he will do this *early* there will be less cause of complaint in the tax and when he comes to the apportionment he will not miss so many things, so *very* many things, which he would like to know. It is not to be expected that two men will make the same apportionment or that the same man in different years will not modify his theory. He does, or should learn something as the years go by. Thirty years ago he meandered all the wet land and took in no *hard* land especially if a little elevated above the marsh. Now he will excuse no islands and capes, even the lands elevated above the necessity of a drain outlet, are perhaps legally slightly taxed for the outlet which they

help to fill—this is a question. By means of water furrows, dead furrows and even furrows in the corn, they are able to send into the main outlet three times the amount of water that *came* in a given time as nature left it, or if it was *now* left unfurrowed they have a right to furrow it, they have the right to pay for the *increased* cost of carrying the water, if, in the judgment of the commissioner, they should so pay. *Where* does your water go to? Who *carries* your water for you? These are legitimate questions to ask, if the commissioner thinks they are. This brings us to the subject of the discretion entrusted to the commission. This is a field in which fatal specifications have never been sown, by the law-maker, and it is to be hoped they never will be. Minute specifications have been the bane of the drain law. Unnecessary specifications are the bane of the drain law today. And, because these minute specifications proved so fatal, they sowed in *more* of them, so as to cure the illness. Yes, hair of the same dog ought to *cure*. Because drains surveyed from the hills down to the river had been defeated in law the law was made plain that they must be surveyed from the river up to the hills and in no other way. And numbered from the river up and the part next to the river must be let first, although the surveyor said it was useless to cut, at ALL, the lowest one hundred rods. And at this late day I dislike to think of drains run one-half a mile further than was needed just to end in a stream or lake, when there was a plain watercourse one mile back and the last forty rods of brush might have been left undisturbed by the ax. The watercourse was perhaps *dry*. But a watercourse is not water. It is the bed and the banks that the water runs in—when there is water TO run. This legal discovery was made by the state of Illinois—and not many years ago. Yet a *dry* watercourse that would do for outlet to a small drain would be only a pretext for the outlet to a large drain. Here is a chance for a commissioner to err. And he has a *right* to—honestly.

While the land which is high and dry can be excused from the ordinary drain tax, because of little or no benefit, the lowest land can also be excused, sometimes for the same

reason, yet that low land will be drier in the dry season and may furnish feed for a time if ALL the water can be brought down in the wet season instead of being spread over the entire year.

While this panorama of foggy views and perhaps fogy opinions and decisions is passing through the mind of the drain commissioner, his eye is fixed on the red line marking the course of the drain angling down through the middle of the map. He knows the land along that line has not only an *outlet* to pay for, but also for the actual *draining* of the land. To partly offset this, *they* furnish the land *for* the outlet, and are bothered with a large ditch. So we see that every part of the map calls for the exercise of judgment and discretion. There are two sides to every question suggested from the center of the map to the blue line border of the district.

He is now ready to consider the matter of percentage. A percentage based upon 100 will be *decided* on, unless there is good reason to adopt a different number.

The first apportionment will be against the township at large, if a township commissioner. If the per cent against the township is heavy and there is prospect of appeal and change in favor of the township, it *may* be well to fix the percentage against the township at large and then make 100 parts of the balance. If the percentage against the township in this event is 40 the percentage will be based upon 140. This will happen but once in a lifetime. A township board cannot order the commissioner to reduce the percentage against the township. Upon appeal within 10 days of review the board may reduce an *individual's* percentage, but they must sign the order and say *where* the percentage shall be placed. The commissioner should not lightly disregard the wishes of the board, but after 10 days and no appeal and he has signed the final order of determination he cannot reopen the apportionment and the case and make a change.

But next we will suppose a case where the percentage is based upon *100* of which 20 per cent goes to the township and the balance is to be spread on 39 names. He will first consider what the percentage of each would be if each man

was served alike. In this supposed case, it will be 2 per cent. Next consider the acres, and see how many acres 1 per cent will cover. If there are 800 or 900 acres, 1 per cent will cover 10 acres. Neither of these *estimates* will do by itself. But between these two preliminary estimates he will be able to fix upon a trial maximum and a trial minimum. Which will be much more than a guess; indeed, it will be a real, *intelligent* trial estimate, nothing estimate and you can proceed at once to write out a tax roll complete in *form* and annexed to your printed notice list. Place extra columns to the right of this list for correcting the trial percentages.

He is not *yet* ready to write the dollars and cents. After the percentages are completed he will foot them up and if they make 100 he has done well. Yet even this accident happened last month in a list of 49 names. This was an accident, but not all accident. If it foots up 90 per cent he has done *equally well*—perhaps better. And after an examination of the map he will be able to add a little here and there until he has accommodated the percentage. If it foots 109 he has done just as well and he will remove a little, in the right places, until the 9 parts are gone. In a few days he will revise this work. It is not likely that the apportionment can be so well done that a man will not seriously criticise his own work in a few days; or in a few *months* when he is taken on the ground and things are pointed out to him, that he did not know before. But he will not go back, too quickly, on his former judgment when the details were fresh in mind. It is impossible to know all about the land above the surface and below. In drafting the map, you may discover a misnumbered stake. You may be able to eliminate an unknown quantity from a simple equation, but no drain assessment ever had all its unknown quantities balanced.

As the drain commissioner not only makes the assessment, but is himself the board of review, he will hear all parties and force himself to take an impartial view of the matter and send one notice to the highway commissioner, who represents the township. There is wider variation of opinion as to the township at large than other parts of the tax. It includes health,

convenience, highway, increased territory for taxation, increased valuation, and what is paid by the township at one time is the source of perpetual income for all coming time. And the country looks better. Good looks are not to be despised even in a township. Where the drain is cut entirely for the benefit of the highway, 40 per cent is even then the limit against the township. It would seem that the *highway* commissioner should do such work. He can at least furnish the tile free to the drain. This is the only way to exceed the 40 per cent, unless the township will vote an appropriation. Of course if the *highway* commissioner could do the work the township would pay 100 per cent.

An apportionment based upon 109, 111, and 142 may be as just as upon 100 parts and a tax cannot ultimately be set aside. But it is *likely* to be misleading. It is not a fraud when based on more than 100. It might be on less than 100. This applies only to the first cutting of a drain. If in the after cleaning it is discovered that omissions have been made it is certainly advisable to leave the old roll undisturbed and add the new names with their full percentage.

During the past summer, a ditch was cleaned in which the number of names was raised from forty-two to sixty-one. The old apportionment was based on 111. Of this twenty-five per cent was on the township and twenty-five per cent on one man and the latter was considered excessive, so the percentage was based on 142 and the individual percentage left unchanged. And to simplify matters still further, one per cent represented one dollar. As one and six-tenths per cent is $1.60 by this, this roll was carried out as fast as it could be written. The Drain Record should show this unusual apportionment and the reason for it, so that all its history will be known, without the old supervisor's roll, which, however, will be found in the county treasurer's office, if necessity compels its use. This necessity often exists and the new drain commissioner is not likely to know anything about it, nor the use to which it can be put. In the absence of any drain record, he will find in this old roll the names, descriptions, percentage and tax fixed upon in the construction of the drain.

This brings us to the construction of the drain assessment roll *itself*. It is made up from two known quantities—the list of apportionment and the fund to be raised. The fund is made up of the expenses which it is known must *certainly* be met. *These* are ditchers' wages, commissioner's fees, survey, tile, lumber and posts for corners and quicksand, bridges, advertisement, making roll, and litigation in Probate Court. But other litigation cannot be certainly foretold, though threatened and must be left out. To the sum of these items ten per cent must be added. Divide this total sum by 100, by 109, or 140 according to what the percentage is based on, and carefully study the resulting *fraction.*

If the *fraction* is *inconvenient* and there are *many* names, it will be advisable to make an unimportant diminution of, or addition to the fund, *such* as will result in a more convenient fraction, or do away with it entirely. By this advice, or rather device, you may avoid endless fractions and an excess of roll. But if in footing up the roll, which should certainly be done, an excess appears, it may be taken off from a few names, leaving the business balanced and the various funds and accounts and reports will then agree to a cent and require no explanation, even of a few cents, or a few dollars. To have these things foreseen is a satisfaction afterward, but it is not vital.

The roll being completed, fill out the determination of assessment, attach the necessary certificate, and then make a duplicate of the whole, and in one of the rolls, fill out the clerk's drain report to the supervisor. Now carry these rolls to the clerk yourself, and at the same time, take all the papers relating to the drain and file them with the clerk. But the maps and profiles ought never to go out of the *office* of the drain commissioner as long as there *is* a commissioner. But he can file the *minutes* of the survey and certify the copy correct. He needs these maps every time a ditch is touched. If the next commissioner is a new man, and without maps, how does he know where private ditches leave off and public drains begin. This very fall, I saw a gang of men working by the day *extend* their work into private ground about forty rods. This did no harm but would not have hap-

pened had the map and profile been with the commissioner.

After filing the papers with the clerk take the roll, signed by the clerk, to the supervisor *yourself*, and compare the names and descriptions on your roll with his, and cause it to conform to *his roll*, as he will be compelled to use his own descriptions and names, right or wrong. If you have one or two descriptions which *his* roll has missed, make arrangements to have the tax returned the next year, as he will decline to collect this year.

Of course the county commissioner has nothing to do with the township clerks, but deals directly with the *supervisors*, and presents his annual report and tax rolls directly to the board, and their clerk, and the clerk is supposed, in theory, to give each his *copy*. But, in *fact*, he does no such thing, and they take each his own roll in charge, the original, from the first, and use it and no other. It is just as well, the statute makes it their duty to see to it, that they go away possessed of the minutes of the tax voted by the board and that they would spread the same. I once heard a supervisor present to the board his *reasons* for not spreading a drain tax voted by the board. "In the first place he did not *approve* of the course the commissioner had taken, and in the next place the roll did not come to him through the proper *channel*—the township clerk." Of course he was liable, by his *own showing*. *Both* his reasons were unfounded and insufficient.

Orders *may* be drawn on the drain fund bearing *interest* from date. This is a simple matter of justice to ditchers, and sometimes to the surveyors, who have to wait one year or more for pay. It enables them to sell these orders without loss. Moreover, if the commissioner will make *announcement* at the letting that he will so *draw* the orders, he will facilitate the sale.

All this drain business is intimately related to the work of the engineer and surveyor. His advice is sought and followed. The new commissioner wants to ask questions unnumbered at every move innumerable because the drain law is so dim.

In conclusion.—These "stray straws" have been partly threshed before. They are now raked together in a pile, with-

out order and unbound. They are of no great value in themselves, but inexperience may use them.

MR. TODD: I would like to ask in regard to that petition. As I understand it, thirty per cent of the signers must be freeholders of the land to be traversed by the ditch; is that correct?

MR. STRONG: Yes; but the form in the books reads thirty per cent of those liable to assessment.

MR. TODD: If I am not mistaken the statute does read that thirty per cent of those liable for assessment on this work must be upon the ditch.

MR. STRONG: Yes; and that is not common sense.

MR. TODD: We have got a case upon which I worked a little Monday. For a ditch that has been dug ten years they find there is not outlet enough. In making a new outlet they cross one man's land a little over half a mile, and that will give an outlet to two different drainage districts. All these parties are going to be taxed for this outlet for half a mile. It wouldn't seem just that this man owning this little piece could block the whole outlet and flood these men's farms and destroy their crops should pay it all, and I don't think the law upholds that. I think that a petition signed by thirty per cent of the parties liable to assessment for benefits is equitable.

MR. SEARS: I move that a committee of three be appointed to confer together and study up this question of drainage laws, and to frame a practical drainage law; I know it is a subject of great importance, and I think Mr. Strong is the best posted man in the society on the subject.

Motion supported and carried.

THE PRESIDENT: I will appoint Mr. Strong as chairman, Mr. Rogers and Mr. Holmes.

MR. TODD: I want to say that there are hundreds of acres of land in St. Joseph county that twenty years ago were bought for from $2 to $2.50 per acre, and for the last three years have been cultivated and paid 20 per cent an acre on a valuation of $350 and $400, and from that we can judge of the importance of this drainage.

COUNTY SURVEYOR'S WORK AND RECORDS.

E. STRONG.

By the program I see that the county surveyor is receiving more than his usual attention this year. I hope this is because he deserves it. It may *be* though, that the courts have set down on his work with such unanimous weight, to say nothing of vigor, that he finds it necessary to bestir himself in order to relieve his cramped quarters. The surveyor feels that he owes but little of his position here below, if he has any, to the courts. He has been treated no better than a horse. The better his reputation, the greater his range, the more certain he is to be lassoed with a subpœna, brought into court, under threatened pains and penalties, and compelled to wear the harness of a witness day after day, while his own business suffers. He is required to submit to the abuse and lashing of lawyers unreproved. The lawyers feed him or not, just as they please—generally not. They don't water him or soak his oats for him when he is hot; and he is hot pretty often. And when they get done with him they turn him out to grass. Even the cruelty to animals act does him no good. If any young surveyor thinks this showing is overdrawn let him ask some old one what satisfaction he ever got out of his legal courting, and how it averaged for a business. There are more stories here to tell than time to tell.

At the instigation of one of the attorneys, his honor will not usually hesitate to tell the surveyor that he is no better than anybody else, and in fact, once in a while, that he is no better than he ought to be, and his evidence carries with it no more weight than another equally incompetant man, who looks just as well and has just as good a standing in the community, perhaps better. He will tell the jury, if requested to do so, that this talk about establishing corners is bosh—that he cannot establish anything, not in this world, any more than the

"heathen Chinee" can, only in so far as his *evidence* may be taken in court, where the Chinaman perhaps cannot testify. But if the Chinaman *could* come into court and have his evidence allowed and taken, he could establish a corner just as firmly as the county surveyor.

There are some in this room today who have heard this style of talk, in high places, and it is time that somebody said something, and presented to the reason, not the prejudice, of the community, the other side of this matter. Especially is this proper when *one* judge in Michigan has set the example and gone back, for *once*, on the time honored prejudices of the State. And how much has this society, in recent years, lacked of saying and endorsing the same things complained of? How much does it lack today?

Two years ago the secretary read before the society portions of a charge to the jury by Judge Buck in the circuit court, in which the "learned judge" used substantially this language, that "When the county surveyor had once run the quarter lines of a section and at their intersection had set a monument for the center of the section and made a record of it, I am here to say to you, gentlemen of the jury, that for all coming time that is the legal center of the section, and the fact that the surveyor did, or did not, do the work according to his best mathematical skill, does not come into the question at all."

This position was not indorsed by this society at that time, nor by Judge Hooker, nor by any decision of the supreme court, or any other court, so far as I know, with the one exception above. Nevertheless, this position may *still* be true.

Suppose we use our reason for a few minutes, and that is one of the purposes of the annual meeting—at least theoretically.

Is it true that the county surveyor is the only man in Michigan who is incompetent to survey and stake an acre of land so that its corners will be established as long as they can be identified? *I* do not believe it is true.

I *think* he can do it nearly every time, that is, every time he makes an *original* survey, accompanied by a deed. He does it, usually, with the consent of one or both of the parties, and

they are bound by his acts. And it matters *not* that the United States is party of the first part.

We all know that any man in Michigan can go into the middle of a field which he owns and pace off an acre and set the corners thereof and give a companion deed for the same, either before or after, or at the same time, and when the delivery of the land has been once completed and accepted and the bargain closed, that survey will be treated as an original survey, and the corners are unchangeably established as long as they can be identified. This is true of *any* man, unless he be the county surveyor.

What, then, is to hinder the United States from doing the same thing, when *it* is party of the first part? and the county surveyor is the instrument especially or impliedly pre-agreed upon by statute, to carry out the bargain of the grantor, as to the interior lines and corners of the section? What honest man can stand up to fairly answer in the negative that question and not feel that his feet are sinking *down* under him as he proceeds?

A native of Ireland, evicted from the bogs because he would not pay the rent, can come here and buy 40 acres of land and sell an acre to a colored man from the rice fields, who has no hat on his head, only a *place* where a hat ought to be, and together they can meander that acre and orient it by the north star and stake it and complete the sale and delivery, and the supreme court will sustain the survey, as long as it can be identified. The court will talk, too, about its being an *original* survey, though rude and lacking in mathematics and not showing the variations of the north pole from the north star. No question about that now. It is only when the county surveyor does the work, that this question is raised. And the *courts* tell us that he is sometimes no better than he should be—mathematically and northstarically—as if that made any difference. Now we come to the sober, serious application of this talk. By statute, the United States proposed to block out the land of Michigan in square miles, and proposed to *sell* the same in 40 acre pieces, or more to all who would buy, on the terms offered, without regard to race or color. Even the

county surveyor could buy, by complying with the terms. I began childhood on a *certificate* calling for the yearly interest. I said he could buy by complying with the terms, and among the terms expressed in the laws of the party of the first part, were these conditions, either expressed or implied, that the United States surveyor, acting under United States law, should survey the outside lines of these square miles of land, and the county surveyor, acting under State law, should survey the inside lines, that the United States surveyor should proceed, in a *certain way*, to place the corners on the outside, and the county surveyor should also, in a certain *other* way, set the corners on the inside. The United States surveyor should set section corners and quarter posts. The county suveyor should set the center quarter and quarter quarters and also all the eighth posts on the outside and the inside. This is as far as the United States, party of the first part, saw fit to go, as 40 acres was the smallest subdivision in the plan of the nation. And when the outside was *once* surveyed, and corners set according to law, and a record made and on file, it was a completed original survey of *those* lines and corners, as provided for by statute. So also, when the inside lines and corners were once surveyed, and the corners set according to the same United States and State *provision* and a record made and on file, it was a completed original survey, of the *interior* lines and corners, in the manner provided for by the same United States statute; and they sold the land by it. And these corners, set by the county surveyor, as the United States statute provides, and as the State law, following the United States statute, also provides, are set in the original survey of the inside and are just as firmly and immovably established as are the corners set by the Irishman and the colored man, as long as they can be identified. *If* not, *why* not? The same thing is known to be true in the original survey of a village plat. But when these original corners of record are once *lost*, on the inside, as well as on the outside, the survey made to restore *them* is no longer an original survey. It is now only a resurvey, and stands on an entirely different set of legs. But it

stands on those legs. And the first duty of the surveyor should be to find, if possible, the original *recorded survey* of the county interior work.

Just so, in surveying for a city plat, the first duty is to find the old survey—the stakes themselves, if possible, by surveying, by measuring, by digging and by evidence. What kind of work would it be, in an old plat, to go on and stake *lots* regardless of original work? It will never do. And is it any better practice, when a county surveyor goes to work regardless of what has happened before to the interior corners of a section of land, comprising an entire square mile?

You *will* confess that it has a bad look. Let us suppose that he *does* look at the old record, and that the county record is full and correct, in every particular, even to the writing in, upon every line run, the variation of the needle from the true meridian, or the magnetic meridian from the true, as the Michigan court has said in Vandergroef vs. Jones, or the variation of the pole from the north star, as the Indiana has it. I quote Mr. Alter. He may be joking. But in Michigan it is no joke. And therein, suppose he finds that the C ¼ was set at the intersection of the one-quarter lines and witnessed. He then finds, on the ground, the bearing trees and the marked stone, unquestioned for twenty years. But at the request of the parties he makes a careful resurvey of the quarter lines. He has a beautiful instrument, as good as Peter Heer can make, and knows how to use it. The country is now cleared of timber. He finds the old center twelve feet out of line. Will he move the old center twelve feet? If so, by what authority? The work of his predecessor has not been declared void, on any docket, and upon its face is prima facie evidence of the facts set forth, and it was set in an original survey. Ah, yes. But his mathematics and his northstarics. It seems to me, that this moving of corners, under such circumstances, is the very thing that the court intends to complain of, and that *we* should condemn; at least hesitate to do. Perhaps *he* will hesitate and set a new one. Fruitful seed of future litigation. It will grow up some day, in the sweet summer time of a lawsuit; in the rainstorm of litigation.

From this new center, he will subdivide one quarter of the section. Another man will subdivide another quarter from the old stone, even when he knows it to be twelve feet out. Which is right? He has himself subdivided the other half of the section only two years ago, using the old stone, and two city plats have been laid out, assuming the old corner correct and the legal center. The old center *is* the legal center and correct today, and the old work based upon it is right, and the new work ought to be based upon it, and the courts will say so some day. That is what they want to say now. No section can have two legal centers at the same time, nor two east quarter posts. But some one will ask, "How about the mathematics?" As Judge Buck has well said, the accuracy of the work does not enter the controversy at all.

This is a matter which this society has never handled, except with gloves on. We pick it up like a hot coal and drop it quickly. The county surveyor modestly refrains from saying too much, for personal reasons, and so, when some one is *pleased*, to say that the county surveyor and his work has the same standing, in the community and the courts, as any other equally incompetent man, he says yes.

Secondly and lastly.

The argument, *so far*, is based upon an original survey and delivery in connection with a deed, in which the first party is the government, or State, and the other is the owner; and the surveyor is employed by the owner to act under directions and provisions of the State and United States made for that very purpose, namely, to carry out the details of the bargain and sale.

The authority of an *original* survey is not the *only way* by which a corner can be established, even by the county surveyor. He can do so by order of court. He can act under statute of Michigan for resetting the posts of a township. He can act under the provisions for reestablishing lost corners of the United States survey, on the exterior of a section, and when lost on the interior, I see no reason why the statute could not provide for reestablishing them if it saw fit to. Perhaps it does not *do* this, except by construction.

When these *lost* corners are once *reset* under the statute and as the statute provides, *a statute for that very purpose*, and by the very man designated to do so, and a record made, *I* am not able to see why *those* corners are not also legally reestablished, as long as they can be identified. Perhaps some one *else* can show how this is all wrong. I will, however, say one thing, that the right to appeal from the act of the surveyor should be good for a reasonable length of time. But after many years have passed, and vested rights and improvements and many lines and deeds have been based on such original or statutory survey, either one, I do not believe the old corners should be moved. Certainly the pretext of mathematical incompetence is clearly inadmissible. Nor should other corners, mathematically correct, be *used*, as long as these exist. If the old center of record is the legal one, no other one *is*, any more than you can have two legal United States posts for the same corner, or two corners for the same post. But if the record shows on its face improper method, or that he did not intend final work, that is another matter. If the record divides the quarter or eighth line north and south, and the new survey runs east and west, the surveyor can exercise his discretion, as to what he will do. He can move the stone to the intersection and make the record *show* what is done and the new bearings. Or he can let well enough alone.

THE COUNTY SURVEYOR.

T. O. WILLIAMS.

The office of county surveyor under the present statutes is a position much sought after by the college graduates, and is now largely a training school for young surveyors. The semi-annual campaign with the chance of having their name on the county ticket along with those of the big political guns of their party is enticing to many, but the results obtained even if successful are such as not to be alluring to the best talent. Hemmed in by law and custom with the same rate of wages as the brick mason; with two or three days' work here and a day there; with all kinds of men to work for, and all kinds of men to work with; with all kinds of swamp, and all kinds of brush to go through; with all kinds of board, and all kinds of beds; and always with everlasting kicking of the man who thinks that a surveyor should be able to locate all corners by simply setting up his instrument; the outlook is not very enticing to the experienced surveyor for a life's work.

There are several things, however, in the position which are desirable to the young man. Such as office room, heat, light and stationery, and above all the great amount of respect and almost awe which is given, sometimes, to the incumbent. For while vested with no authority which makes his surveys any more binding or the location of his corners any more decisive than those of other surveyors, still there are many who think that they are obliged to abide by the decisions of the honorable county surveyor and accept his lines and corners without question. Disputed lines are referred to the county surveyor for settlement, although he may be and often is a stranger to both parties, they relying entirely upon his title for the correctness of his work. The survey of sections upon the petition of a majority of the resident land owners belong to the county surveyor's office, and the field notes and plats of

the government survey of his county are in his custody. These facts are of great aid to the young man in getting a start in his business and an acquaintance throughout the county, and also much valuable experience at the other fellow's expense.

If to the present duties of the county surveyor could be added the duties that should, in my opinion, under properly constructed laws devolve upon the county road engineer, such as the location and surveys of highways, the establishment of grades, the drainage and permanent improvement of the roads of his county, also the general supervision of all bridges, their location, construction, general design, and final approval of the finished work; also of the major portion, if not all of the present duties of the county drain commissioner, could be turned over to the office of county surveyor and be added to his present work, then the office of county surveyor would cease to be the training school, and would be an office which would command the best of talent and would bear nearly the same relation to the county that the city surveyor does to the city. To increase the similarity between the two offices and to put them on more nearly an equal footing, the county surveyor should be appointed by the board of supervisors, and be under their control either directly or through a committee appointed by the board or by a commission elected by the people, and should be entitled to a regular salary commensurate with the duties and responsibilities of his office. Then we would have an intelligent, qualified head, to all our road improvements, all bridge work, and all drainage matters, which would result in a great saving to the county not only in the cost but in the efficiency of the work done.

THE PRESIDENT: We have the papers, and I would like to hear the questions practically discussed.

MR. HODGMAN: I apprehend that in the case to which Mr. Strong has referred, the court might not be considered entirely out of the way. As the society well knows, I have been quite free to express my opinions on the supreme court of Michigan whether they did their work according to law or not, and I am getting to the time now that I don't feel quite so aggressive as I used to about some things, and if I did I have

not the physical nor mental capacity to go ahead as I once did. I believe as Mr. Strong does, that an original survey made by the county surveyor is the legal one; and that it should be followed; I believe that should end it; but it must be shown that it has been done according to law. In this case that has been referred to, the record itself showed that the center of the section was not set according to law. That survey, no matter whether it was right or wrong, should be final with the parties who accepted it; but mind you, that center of the section concerns quite a good many people besides the two parties to that survey, and if it is shown to not be set as the law directs it should, it should not be final upon any one else except those two persons who were concerned in it and accepted it as such. I believe Judge Buck's position is correct, that where the survey is made in accordance with laws directing how the survey shall be made, that should be the end of it; that it should be accepted no matter whether it is mathematically correct or not, and I believe when the case is fairly and squarely presented before our supreme court they will sustain that point.

THE PRESIDENT: We would like to hear from Prof. Davis.

PROF. DAVIS: The case that Mr. Strong presents, speaking of the subdivision of a section, is a matter of the United States statutory law. Let us remember that in subdividing the township and setting the original section corners and quarter posts, the thing that makes those locations legal is the returns which the surveyor makes and which are placed on file in the land office at Washington. In the first place, if the county surveyor's or any other surveyor's subdivision of the sections marking the interior corners is to stand as the marking of the section, this is but a part of the United States law. The returns should be made under the United States law, and there should be some provision for making, receiving, accepting and filing those returns. Otherwise, it seems to me that the interior corners marking the legal subdivisions, however carefully made, can have no standing except under the common law, which would be by their acceptance as boundaries and land marks by adjoining property

owners, binding only those immediately adjoining farms. Those considerations seem to have a little force in this connection.

MR. BAILEY: Now as to the paper on county surveyors by Mr. Williams. If the board of supervisors was to appoint the county surveyor, he would be in the same predicament he is in today; the dominant party would be sure to get there. For that reason I say let the county surveyor be just where he is; I wouldn't disturb him; I wouldn't make any more law, that is all. I shouldn't have anything to do with it, because county surveyors are elected by political parties, and the surveyor that has got the right kind of a stripe can put on the right kind of a coat every time, and he will be county surveyor. Before a man attempts to be a county surveyor let him learn his business, and he cannot learn his business in any other way but by surveying. But on the top of that he must have a training, such a training as that given at our State University or at some other places. Let the man who can do the best work and do it the most correctly, and tell how he did and why, and give all the whys and wherefores,—let that man stand before judges and juries to tell the facts.

MR. SEARS: I would like to ask Mr. Bailey if it wouldn't be a good thing to make this society an examining board to pass upon the qualifications of the surveyors?

MR. BAILEY: You are just happy right now, just shouting good and loud.

MR. SEARS: I would like to say to the society—I don't know whether fortunately or unfortunately—I have been a surveyor for thirty years, and I know how these things run, and I do think there should be some standard of qualification for a man to be elected as county surveyor.

MR. BAILEY: His suggestion, I tell you, is a good one, and I wish we had a law that at least three members of this society would be an examining board for every individual making a survey in the State of Michigan, and get his license from them.

MR. SEARS: He ought not to be allowed to practice unless he could show it, even if elected.

MR. BAILEY: I would put him upon the same footing that doctors are.

MR. HODGMAN: I would ask Mr. Bailey if he would let any of the Agricultural College men be on that committee?

MR. BAILEY: I wouldn't care anything about the Agricultural College or the University of Michigan, or any other college; I don't care where they come from. I would say three members of this organization should be competent to examine every applicant that wished to practice surveying in the State of Michigan. Engineering is another thing; but if he wished to practice surveying he should have his papers to show that that committee had said he was competent to do so.

PROF. PASHBY: As a matter of fact, at the Agricultural College, we don't pretend to send out accomplished surveyors. The time we have to devote to that work is not sufficient to qualify men for that work; but we cannot exact from them an oath that they will not obey the dictates of their party.

MR. BAILEY: Our Agricultural College does not go far enough; it gives a man a smattering of the work, just a little bit, but it don't reach the point to give him a thorough education in that particular line or a technical one; that is what the man needs if he is going to be a surveyor.

PROF. PASHBY: I would ask some of the representatives from the engineering school at the University if they would recommend their technical graduates as county surveyors with no more practice than what they get from the class room instructions.

PROF. DAVIS: I am responsible for some of the surveyors of the University of Michigan, and I freely state that I do not teach land surveying, and I have said thousands of times to students that the only way to make a land surveyor is to survey land, and however good an education they may have in school, and how much practice they may have obtained in school, they must still serve, not such an apprenticeship as young men like to serve, but I would say about twenty years; and I do not think, to give an explicit answer to the question, that any student graduated from any school on earth would get my recommendation as a competent land surveyor. It is

only to be learned by years and years of practical experience at the thing itself. There are so many questions of law, so many questions relating to records, so many questions relating to the interpretation of deeds, so difficult to ascertain what has been done, and not done, and undone, that it is impossible for any man, no matter what his practice in school may have been, to take up that branch of work and call himself thoroughly competent in it, in my judgment. I do not think the University of Michigan or any other university or technical school anywhere makes the man a competent land surveyor. It gives him the necessary preliminary training; that is all we can hope to do, and we do not pretend to do that. Our surveying is taught more in the direction of engineering. Surveying is the basis of engineering work—laying out work, making charts, making hydrographic and hydraulic surveys, making profiles, lines of communication and things of that sort, the elements that are to be used along those lines rather than the elements that are going to be used by the land surveyor. Incidentally they learn the use of the instrument and some of the methods in the field which are of use to a land surveyor, but are not taught exclusively for that purpose. I have given special courses in land work, and gave one last year. When a sufficient number of students present themselves for a special course, we give that course. Now, if the gentleman will accept this as an answer to his question, I will let it go.

MR. TODD: I think from what has been said, and it seems to be agreed by all, that the county surveyor ought to be a pretty good man and ought to understand something of his business; as Mr. Davis says, he would want twenty years to finish it. I have been a land surveyor for twenty-six years, and I have found out there is a lot that I don't know about land surveying; probably a good deal more than I know about it now. But from my experience I will say this: That I believe a man that is a competent land surveyor must have just as good a head on him and have as good common sense and persistency and energy, and all that goes to make a man, as the man that built the Ferris wheel, that erected the St.

Louis bridge, or any other great work in this country. But the county surveyor belongs to a party; he is nominated by that party, and elected if he gets votes enough; he may be, as the case was in our county once, where a man was elected who never saw a transit. Now our friend Bailey thinks we better let the county surveyor go as he is; I don't think so; I think it is important that we have a good man for county surveyor, and I think we should have laws compelling him to be a competent man, and I do not believe any man ought to be elected or allowed to hold the office of county surveyor unless he has a certificate of examination from a competent tribunal. Would the laws of this State allow a man to be elected county attorney if he did not belong to the bar? They would not allow a man to practice as a physician unless he had the proper diploma. Then why should a man be allowed to go on and determine the rights of certain people as to property if he is not competent? He might do a great deal of harm. Why not insist that he should be a competent man? Now as to the graduates of our colleges, I don't know as there is any difference, so far as my experience goes, between the graduates of the State University and the Agricultural College; they don't either one of them know anything about it when they go out. Suppose you take a graduate from either the Agricultural College or State University and send him to locate a section corner. Now we all know about the government surveys, that they are very inaccurately done; there is not one case in a hundred that is accurate; in my experience of twenty-six years I have found just one case that was accurate in the field notes. What would the man of no experience do? Now the man of experience who goes out to do that work will perhaps stop a day or two, as the case may be, and go and pump every old settler he can and get all the information possible before he sets his transit at all. Perhaps he will go off twenty miles to see some old trapper that used to be in there, and find out what he knows about it and perhaps bring him there on the ground to get what information he can from him. Now by that time he is ready to commence work. Years of experience will tell the practical surveyor many things, and there are

many things that no one can tell just how it is done or why it is done, that the county surveyor or the land surveyor must take into consideration. At times he can lay aside his transit and take up the shovel and pick, the best of all implements, and work, perhaps two days, as I did once, and if there is any evidence of the corner remaining, there is some chance for him to find it. Now I ask you in all good faith if this young graduate from the university or college is apt to do this thing? Isn't he more apt to make others dig to see where it comes? Now I think the county surveyor's office ought to have a man that would be surrounded by some safeguard in the way of a certificate of competency so that the county surveyor would not be looked down upon as a generally incompetent person. I am in favor of legislation that will compel the county surveyor to be a better man and understand his business better. I think it should also be proper for the county surveyor's office to perform the duties of county drain commissioner and have charge of the erection of all iron bridges in the county above a certain capacity, a certain length perhaps, and make this such an office that the county surveyor can afford to be a good man; he can then afford to spend some time in his preparation for it, and travel the swamp and the forest and so on, lie out night after night if necessary, in fact spend the best years of his life in perfecting his work. But as long as you make it a political office, the man that shows the biggest hand takes the pie. What are you going to expect? Is not the county going to get all it gives for this service? I think so.

MR. DAVIS: I would like to make a brief reply to what Mr. Strong said. Speaking of the county surveyor being called upon to find a law of the State relating to the subdivisions of sections and matters of that kind, and having conformed to the law of the State, that is that records should be made prima facie evidence of the things that he has testified to and that his monuments should stand as the true corners which they were intended to represent, I wish to say in response to that line of talk, in the first place Mr. Strong sets up the belief that the State law follows the United States law. In answer to that proposition I would say, who has decided or who shall

say that the State law follows the United States law? In the second place I would say that the State is making a law on the subject that it has no business to. What the United States statutes can dispose of, the State has no business to make laws upon. If the State has a right to make any laws supplementary to the United States statutes, I should judge it was for the purpose of carrying out these statutes. This is especially true of the land surevying matters, and there are explicit methods provided by the United States statutes, and it is a matter entirely beyond the jurisdiction of the State, and I have steadfastly contended for more than twenty years a matter entirely beyond the jurisdiction of the courts of any state. I have been asked how this thing should be done and what the statutes of the State of Michigan were relating to these matters, whereupon I have said I didn't know, and have sometimes said I didn't care to know, for it was none of my business, and I don't see how the county surveyor's work in subdividing a section and establishing the interior land marks can become settled, fixed and established in the sense that they are section corners and quarter posts unless the United States provides methods for the surveyor to make his returns, and these returns are made as they are now, except that the county surveyor's work may become established through the lapse of time, like any other mark.

MR. TODD: Mr. Davis telling them that he didn't know or didn't care reminds me of a little incident that occurred in one case in our court. An old gentleman was on the stand, an old man about eighty, and the prosecutor was a young man, and the old man described how he ran the lines, etc., and the young attorney said, "Why didn't you commence at the section corner?" The old man took off his specs and said, "Young man, that is my business."

PROF. DAVIS: Perhaps I can state my point in another way a little more plainly. I don't see any manner of setting up any line of decisions, or of the State or State courts setting up any precedents which will make a wrong corner on the interior of the section binding upon parties not concerned in setting that corner, who owned land on that section.

MR. TODD: This point of law that has been brought up seems to me to hinge right here: Upon the original survey, whether made by the government surveyor or a county surveyor, taking precedence. Judge Buck seems to have held, and it seems to me logical, that the original survey of the interior lines of a section is the first survey made by the county surveyor, whose notes show as part of the record, and the record shows that it was made according to law; if the surveyor comes in and makes a survey, that being the first and original survey, and all the notes and all the matters of record show that he conformed to the law, I don't see where the question of his accuracy could be entertained.

PROF. DAVIS: Suppose a man owned the west half of the northeast quarter and another man owned the west half of the southeast quarter, and the county surveyor in subdividing the section, sets the center of the section wrong, and makes his records according to the law of the State. Sometime after another man, not concerned in that survey, calls for a survey to locate the west half of the southwest quarter. Is he bound by that wrong center?

MR. TODD: I believe he is.

MR. DAVIS: I don't believe he is.

MR. TODD: The legal center I claim to be the one that the records show to be the legal boundary; now if that center is once established it governs every other corner of every other subdivision in the section.

PROF. DAVIS: You hold the doctrine, then, that within a section a surveyor can go and make a survey for one party and get his survey wrong and have that survey binding on the other land owners on that section?

MR. TODD: If an original survey made by the authority of the State of Michigan is of the same force as an original survey made by the authority of the United States government; then I don't see why that original survey made by the county surveyor, although it may be wrong, has not the same authority of law as the quarter section on the west boundary which is two rods too far west.

PROF. DAVIS: Because he didn't operate under the United

States statute, but under the State statute. The State has no authority to resurvey a matter which is already certified by the United States.

MR. HUBBELL: Is there any way for a party owning land to have the United States follow up that survey—can a deputy United States surveyor follow it up and subdivide the section and make his reports to the United States?

PROF. DAVIS: No, sir; only in this way as the only case that I know of. The United States government may for some reason or other obtain a reservation like a light house reservation and send a properly qualified deputy to perform this subdivision. Where it is under the discretionary departmental powers of the Interior Department and the Commissioner of the general land office, it might be—I do not say it is, but it might be authority to deputize some person to go and subdivide this section and make returns for the purpose of setting off this government reservation, and if those returns were properly made and accepted by the general land office, I should suppose that that subdivision survey would have something of the force of the original marks of the section line.

THE SHOP FOREMAN AND TECHNICAL EDUCATION.

CLARENCE E. BEMENT, LANSING, MICH.

After the superintendent, the results obtained in manufacturing depend on the quality of the foremen at the head of each department, and in their hands rests and on their ability depends, the turning out of good work with economy, efficiency and speed. These men are rarely known or heard of outside of the institution in which they are employed, and nobody but the active head of a manufacturing institution knows how much his own reputation and that of the business, is dependent on the brains and ability of the shop foremen.

In ordinary manufacturing plants employing from 300 to 600 men, there will be a foreman for every 50 to 75 men, and it is doubtful whether a greater number can be advantageously handled by one man, except perhaps in special lines of manufacturing. Certainly not in manufacturing involving considerable detail and change of work.

The shop foreman takes the work as received from another department, or the raw material, as the case may be, and after performing upon it the work of his department and inspecting it, passes it on to the next department foreman. By the time the finished work has reached the warehouse, it has passed through the hands of, say a half dozen foremen, each one of whom has left upon it indelible traces of his individuality in the shape of good or bad or indifferent skill. It is evident that the foreman of one department is helpless to correct the blunders of the man from whom he obtained *his* raw material, save by "kicking" or sending the work back. So that the outcome of the matter is that one bad foreman out of half a dozen may counteract the good work of all the others and leave the superintendent helpless to deliver first class manufactured product to the warehouse.

You supply a foreman with men and machinery and work to

do. He has drills, planers, shapers, drop hammers, punches and shears, emery wheels, and all mechanical appliances for producing his work. But the amount of work produced, the economy and efficiency of its production, will depend not on the maker of the machine, nor the number of revolutions it may make, nor on the individual who runs it, but on the skill and ability of the foreman who directs the running of it. On him usually depends the making of the jigs, patterns, forms, and the thousand and one labor saving and efficiency producing appliances found in every department of a manufacturing plant. He is the one who suggests that the man who drills by the piece pays for his drills, and thereby cuts your drill bill in two. That the boy who taps nuts and breaks a tap to every 50 or 100 pounds pay for his taps, and thereby cuts your tap bill from $250 per annum to $50. It is he who makes the clumsiest and simplest machine in the shop, "The Bulldozer" perform every operation on iron and steel that they will submit to. Who makes the drop hammer forge unheard of shapes and the punch punch holes in impossible places, and the shears shear impossible shapes. All these things and a thousand more that any superintendent will call to mind are generally the work of the shop foreman, and not of the superintendent or the more conspicuous members of the working force of an institution.

The shop foreman, then, is one on whom you must depend for good results in manufacturing. If that is the case it will be interesting to know something about him. Where does he come from? What is his preparation for his work? Who educates him and what is that education? How much of a man is he outside the shop and what compensation does he receive? Is he as good as he could be and how will you make him better?

In nine cases out of ten he is a boy who has left school at the age of fourteen or younger, from choice, or, more often, necessity. His education has ceased at the sixth or seventh grade of the grammar school, and he starts in to earn a living with the scantiest kind of an educational equipment. In the shop he starts as an elevator boy or "bolt" boy, i. e., keeping

the piece workers supplied with their small material in the shape of bolts, etc. After playing "devil" to the whole shop for a year or two, he is promoted to an emery wheel or drill or helper at a forge or drop or trip hammer. If he shows mechanical ability and skill and common sense, his improvement in position and wages is fairly sure. If slow, at the end of eight or ten years, if he is made of the right kind of stuff, he is in line for the first foremanship vacancy that may occur, and if he has patience his turn is almost sure to come. But he has traveled a long hard road, has worked on every machine in the shop, has mounted every tool that the manufactory turns out and has perhaps had his spell of becoming disgusted with the institution and going off to find out for himself that there's a deal of sameness in this world and in the men that run its manufacturing plants. Finally at the age of 28 or 30 he has made up his mind to take his chances with this particular institution and stay by it for better or for worse. When the crucial day comes, and there is a new foreman wanted, and the superintendent and manager and all hands put their heads together to decide on the proper man, there is generally very little trouble in picking *him* out. The men in the shop know who the next foreman will be long before he is chosen, because they, better than anyone else perhaps, know who the most competent man is. What is the equipment with which this man enters upon his new duties? If it is not the equipment of theoretical or "school" learning, it certainly is that of long, hard mental and physical discipline, during which he has met all the "practical" snags that arise in the conduct of a manufacturing plant. He knows from unpleasant experience where he'd better use a bolt instead of a rivet, and why. What size of belt *that* machine needs, and at what rate of speed that other one should run. Every piece of every tool that the institution makes is as familiar to him as the face of his own child. He has gotten his best education perhaps from the blunders that have been made by himself and other men. He knows why the last tool that the plant turned out was not a success and where the weak spot lies. He knows from practical experience whether this piece should be iron or soft steel

or spring steel. Whether cast or malleable iron will be required to stand the strain in this other place, and so on through all the complications that are constantly arising in manufacturing goods of steel and iron for the market. This practical education has not ordinarily been supplemented with very much theoretical learning. But it is very short-sighted to draw the conclusion that a man trained as I have described has not received the very best kind of an education. Certainly there is no mental discipline like that of hard knocks; the meeting of obstacles and overcoming them.

While good foremen are men that command good wages, they are seldom men that have received any technical education except that of practical experience. It is very doubtful in the first place whether a young man who has acquired his knowledge of mechanics by three hours a week in the foundry and two in the blacksmith shop and an hour a week at the lathe for a few terms, would make a good shop foreman, and it is fairly certain that however little he knew he would not consider the job worthy of him. Isn't it a little strange that educators should expect that young men turned out with that kind of a smattering of mechanical knowledge should be able to go out and compete with a man who has worked at the forge or the lathe for five or ten years, and has had an ache for every idea he's received? Isn't it a mistake to give young men the idea that when they have graduated from a technical or mechanical school of any kind, they are prepared to go ahead and do business? They need another four years a great deal more than the one that led up to their diploma, and at the end of it if they have common sense and a little brains they may be able to compete with the man who has "hammered it out of the solid bar." This may be misinterpreted as a screed against technically educated manufacturers, but that isn't my idea. The manufactory needs more brains, and more educated brains, but few institutions need more conceit. What is wanted is more men that are willing to let *you* find out how much they know and gain that knowledge from what they can do. We want more educated mechanics who are willing to occupy some position below that of general manager or super-

intendent, and are not in so much of a sweat for promotion as they are to show that they deserve it. Every manufactory needs better, and better educated shop foremen, but they want men that know what they know from having stood the hard knocks of learning, from having done drudgery that any roustabout could do, and learning from actual experience how many wheelbarrow loads of castings a man can handle in an hour because he has handled them, as well as how many cuts across the face of a pulley could be made in the same time.

The "practically" educated shop foreman has several serious failings, arising primarily from his lack of technical knowledge and the narrow view of things that his narrow horizon impels him to take. He has no faith in new ways of doing things, and very small obstacles are apt to assume mountain size to him. He, too, is liable to become stuck in a rut that he can't be gotten out of, and to cease to improve after he gets to a certain point and age. But with all these drawbacks he represents in most factories the solid backing of skill and brains from which the institution must draw its inspiration in the management and conduct of its business.

It is perhaps too much to expect that manufacturing shall be done in the future by shop foremen who have graduated from a mechanical school and learned their trade *besides*, but it is certainly a fact that many college graduates would be as well off financially, if not otherwise, if they learned to be good shop foremen.

THE PRESIDENT: You have the paper of Mr. Bement before you for discussion.

MR. HODGMAN: I guess Mr. Bement has not only hit the nail on the head, but driven it home.

THE PRESIDENT: The subject of handling men is one which technical schools and technical institutions deal with very slightly, I believe, and a great many young engineers have found hard times in the management of foremen and the selection of men. It is an education in itself. I have seen young men from technical institutions who were very bright in all that goes into the course of an engineering curriculum, but they lacked in executive ability to handle men. I think Mr.

Bement need not come before us with an apology for giving us practical points. I would like to ask a question. In your institution, do you hold your foremen responsible for results?

MR. BEMENT: Yes, sir; we hold our foreman responsible for the results in his department of the cost and quality of work; I never go to the head of the department to get at the individual under him under any circumstances. This class of men very probably have certain ideas of what their rights are, and you have got to take that into consideration. We are all built a little in that style, and the shop foreman is the same, with the rest of us.

THE PRESIDENT: I have found in my work that you must establish a respect among the men for the foreman, and you cannot do that in any other way, so far as I have found out, than to place the responsibility on the shoulders of the foreman, hold him responsible for his work, and never get at the work in any other way than through him, and if he cannot get the work done for what experience shows it ought to be done make a change in the foreman. If he discharges a man give him the moral support of being allowed to be the judge of that man, and forthwith so far as you are concerned that man is discharged forever. In my work if a man is discharged by a foreman we do not permit him to work for any other foreman on the job. If he can fix matters up with the foreman who discharges him, we have no objection at all; but he cannot run from one foreman to another and disorganize the work and throw you out of a great deal of money and time.

MR. SEARS: My instructions to young men have always been to do their work a little better than anybody else, and then you can promote them. That has been my theory always. If he is a slouch, doesn't do anything with care and you can't rely upon him, you don't want him around; you want him removed at once. He should serve his employer faithfully, trying to advance his interests, and if he will do that he will hold his place and be promoted. But if he is late in the morning, careless, wants to keep his hands a little too clean and don't want to soil his clothes, you don't want him. I like a

man that can get right down into the ditch and do his duty with anything he undertakes, and do it honestly.

MR. APPLETON: I was just going to say I don't take it that Mr. Bement thinks that a young man is any the worse because he has had a technical education. I think he has very tersely expressed the idea that some young men have and that is that as soon as they get through with technical schooling they are very apt to be more inflated with what they don't know than what they do know. Having passed three or four years in school, they think they know it all, and feel too big to learn any more; and I think any young man, or old boy, when he gets too old to learn anything is almost too old to have any useful place in this world.

MR. BEMENT: There is an impression among all kinds of people that a college or university or technical school can do what nothing else in this world can do—can make a wise man out of a fool. It cannot do it; if a bright young man goes to college he comes out a bright young man, and if a fool goes to college he doesn't come out very much less a fool than he went in. A good many people seem to think that the fact that a man is graduated from any kind of a school or college is evidence that he knows it all.

MR. HODGMAN: All the same, if a man has a good technical education, if he is a bright man, it will make him all the better when he comes to practical work.

MR. TODD: I would like to ask if it is a fact that a young man entering a shop and becoming proficient in a certain line will be promoted further, or will he be kept in that place that he so well fills, although it be a subordinate place. Is there an incentive for the young man who aspires to rise higher and higher? I ask this for information, as I am not posted in regard to the manufacturing business.

MR. BEMENT: I don't think there is any question but what every manufactnring man is hunting for talent all the time; they are only too happy to recognize any man that has any kind of ambition and give him a show, because it is for their selfish interest. They cannot get good results unless they have good men, and they cannot afford to keep a man in a sub-

ordinate position when he shows he can fill a better position. I think there is no question but that the man that deserves promotion gets it; I have never seen the time when a first-class man didn't get pretty much what he was entitled to.

MR. SEARS: I didn't expect to say anything, but this question has come up, and I would like to answer it. I have been an employer of men for forty years, and when you find a young man with the right kind of stuff you cannot keep him down; the manufacturer cannot keep him down. I have had men in my employ that if I should try to keep them down I couldn't do it; they had the right kind of stuff in them, and they would come forward in spite of me, and it is so in every large manufacturing concern. I presume Mr. Bement has had the same experience, that he has had young men come in there that if he had wanted to keep them back a little they would get ahead in spite of him. That is one great element in the American people that you cannot stop. A man who is a natural born mechanic or manufacturer or electrician seeks to get into that business; you cannot keep him down. If your shop won't let them get up, Mr. Jones over to the other shop will do it, and he will have him there. I have had boys come into my office whom for a year I thought wouldn't amount to anything, but subsequently they came to be the most useful men I had in my employ.

PROF. WEIL: A great many people criticise technically educated men from this standpoint, and I will illustrate it by a little story. A young engineer goes into an engine room of an establishment where the man has been employed seven years. There is something wrong about the engine. The young trained engineer and the running engineer come in contact. The running engineer says, "What is the matter with my engine?" The young man says, "I don't know." "What, you don't know? What is your technical education worth?" He turned to the engineer and says, "How long have you been here?" "Seven years." "And you don't know what the matter is?" "No, sir." "Well, if you have been here seven years and don't know what the matter is, you might give me ten minutes to find out." That is the attitude of some people at

this time. They expect the young engineers to answer questions which sometimes they themselves have a little difficulty in answering after a good many years' experience.

FORESTRY.

F. E. SKEELS.

Your committee on forestry, to whom was referred the subject entitled "To Study the Climatic Effects of the Removal of Forests and to Report Plans for Preserving the Same," has at least one member who is not ready to make such a report as should be given upon the unsettled topic of the "climatic effect of the removal of forests."

So many conditions and effects enter into the consideration of such a topic that even an approximately correct solution can be given only after long and careful experiments and a gathering of statistics from time back—when we really had forests—and a comparison of past and present conditions and results.

That the removal of our forests has an effect upon our climate is undoubtedly true; but whether this effect is direct, or whether the condition is brought about by a number of results from cutting large areas of timber, can be decided only by a long study and careful experiments. The climate of any locality must depend in some measure upon the air currents and the amount of moisture contained for any considerable time in the atmosphere. These two conditions, at least, we may safely say are largely dependent upon forest areas, and to demonstrate the former, one has but to spend a typical March day upon any large area stripped of its timber. He will take to the woods the next day, and the change in position will also show a good, healthful change in climate. Excessive drouths are always accompanied with a dry atmosphere. The moisture in the air will depend somewhat upon the height of the ground flow of water, and the depth of this water will be variable to a greater or less extent as is the flow of the streams which drain the given area. The study of the effect of deforestation, then, upon stream flow may be directly connected with its

effect on climatic conditions; and the less variable those conditions, the better is the climate. It is obvious that excessive stream flows will be governed by the rainfall of the area, and the time in which this water will be carried off from any district will be fixed by the amount of obstruction the water encounters in reaching the streams. Whatever matter holds in check the water accruing from any rainfall becomes a storage from which the streams draining the area draw their supplies. Thus we find that streams having source in a water shed covered with forest growth have a more regular flow than do those rising in cultivated areas, and there is still more difference between the forest stream and those on barren plains. The reason for this we assume to lie in the fact that the soil of the forest areas is composed largely of humus which possesses the power of absorbing and retaining large amounts of water. Especially is this true of swampy tracts where the sphagnum and other mosses retain the water in large quantities; the decaying wood, leaves, and the irregular surface of the ground which is usually found in forests hold the water falling upon such tracts in check until it gradually works off through channels afforded by the roots of trees or other vegetation. When a rainfall continues after this storage ground is saturated, or frost prevents the storage of the water, the result must be a flood; but it may be remarked here that the volume of flood in an extensive wooded district is much less than in a deforested region in any example where a fair comparison can be had.

These deductions are not a matter of experiment, for the making of which we have had no opportunity, but are rather from observation during our extended tramps in the woods covering some years of time. Much space can be utilized which is unfit for cultivation, by covering steep slopes, and this can usually be accomplished by protecting from fire, the evils of which, resulting from the cutting of extensive tracts of timber in this State, are brought so prominently to our notice that we need no further experiments to show the necessity of preserving a proper amount of forest.

Just how this shall be accomplished is one of the prob-

lems which we are given to solve. There are now less than one hundred thousand acres—about four townships—of good forest lands left in the lower peninsula which are still under public control. This does not include State tax lands—which have been stripped—or the poorer quality of State swamp lands, because neither of these can be classed as timbered lands in any respect. The balance of remaining timbered lands are the property of private individuals or of corporations, and could all be laid low on a single year if the owners so desired. Inasmuch as we cannot depend upon the philanthropy of these owners to retain them in their present condition, we must look to the "powers that be" for some way to preserve our forests or we shall soon be literally out of the woods.

Our forefathers had little use for the timber which had to be cleared away in order that they might eke out an existence by getting at the soil; but a little later on we find Michigan timber being called for. And at the first call many men acquired large tracts of magnificent timber in various portions of the State at very low valuations, and we find almost without exception that these individuals are the owners of or have left estates whose values rate among the millions. What has become of the lands? Take a trip along any of our northern railroads and see for yourselves. Hundreds of thousands of acres of what was once the finest timbered land of its kind known to man stretches away on either side of the track as far as one can see, for there is nothing left to break the vision which are the monuments of what we once were. Do these but tall blackened trunks, and thousands of blacker stumps lands still belong to the original purchasers? Hardly; as soon as the timber was cut the taxes were allowed to go unpaid and the lands reverted to the State where the title will probably remain for some time. As we go farther north in the lower peninsula we find lands which have been more recently cut over, but these are going the way of the first. During our examination of college lands we have noticed many tracts of land which were cut over some years ago which now have a second growth of Norway and white pine large enough to cut

again and some have actually been lumbered a second time by men holding a tax title for some single year.

Thus the State is rapidly gathering back to itself many of the lands which it once owned as forest, and these tracts, added to those held in trust for public institutions, make a large area. These men who have built great fortunes out of Michigan pine can afford to add to the area such lands as they have taken the timber from, and we would suggest that there is an easier and a shorter way of accomplishing this than to allow it to revert by non-payment of taxes. With these lands already acquired and to be secured, and the lands which are held in trust, let the State adopt a plan such as any business man would use, and such a plan as owners of large timber tracts now follow, and we would have the forestry matter well in hand. Enough timber can be disposed of each year from that which is mature or fallen to pay the expense of a competent man to look after it, and in time the State would have again acquired a tract of valuable timbered land by simply protecting nature in her work.

In taking this step Michigan will be no pioneer. New Jersey, New York, Minnesota, Wisconsin, and Ontario have taken steps to stop the ruthless waste of timber which, as one person has said, is sufficient annually to care for all our public institutions. In the counties of Oscoda, Iosco, and Alcona, are large tracts of so-called "Jack Pine Plains" which have been burned and burned again until not even a jack pine remains in some locations; but there is good evidence that these plains were once covered with a valuable growth of Norway and white pine, and any breaking up of the soil by the plow, as is often done to prevent the spreading of fire, is always followed by a rank growth of young pine seedlings. With a little care these plains could be again covered with timber—perhaps not all of it valuable, but the major portion of it would be vastly so. The State holds in trust for the Agricultural College about fifty thousand acres of these plains lands, and about five thousand more of the primary school and swamp lands in these three counties, and there are thousands of acres more which have been or soon will be acquired as State tax lands. The

Au Sable river flows through the tract, the larger portion of the lands lying on the northerly side. This territory is very sparsely settled for the reason that the plains give poor returns for cultivation, the only profitable use being in their value as grazing lands. Incidentally it may be remarked that in no other location in the southern peninsula is there such an abundance of game as is found in this tract, and in no other locality is there so good a chance to unite the preservation of forests and our native birds and beasts.

Hon. C. W. Garfield is, and has been in the past, one of the most earnest workers along forestry lines; and in a recent interview he remarked: "It is admitted by the most common foresters that the work of preservation of our forests can only be accomplished with holdings in large quantities under one management, and one has only to look at the maps in the State land office upon which are registered the descriptions of lands that have reverted to the State from owners who have swept off the valuable timber, to see how Michigan fulfils this condition. There is no question that can come before our State legislature that is of greater importance than this. The matter of cutting down the appropriations, asked by our public institutions, in the interests of economy sinks into insignificance when compared with this. The annual loss by neglect would care for them all."

What is our plan for bringing this all about? We must first interest those who control the greater portion of these lands, for we cannot expect any assistance from large land owners until the public at large shows a disposition at least to do something to check the further destruction. The State Agricultural College still has about one hundred thousand acres of land, the residue of the amount in its original grant from the United States. This college is under the control of the State Board of Agriculture, who also control, with the Commissioner of State Lands, the college lands. The State swamp and school lands are directly in charge of the State Land Commissioner. Let our representatives make our State Board of Agriculture and State Land Commissioner a forestry commission to devise a means of protecting our forests and

give them authority to dispose of mature and damaged timber. The making of such a commission will not create a single penny of additional expense, and the saving of timber which is now being wasted will much more than over balance the expense entailed by any person appointed by this commission to look after the forest lands. There are no more enthusiastic men on forestry in Michigan today than those who would constitute this commission if the positions now held by them were retained, as nearly all of them must be for at least two years more. This would be a step in the right direction, and the developments of the ensuing two years would point out what changes could be made for the better. This question of the preservation of forests is one that should be met squarely by our legislature, and definite action taken. No extensive lumberman or large timber owner exists who does not look after his interests in his timbered lands by having competent men look after the stock on hand to prevent losses from waste. The State certainly cannot afford to adopt a less careful method than an individual in caring for its property.

FORESTRY.

J. J. HUBBELL.

The original forest growth of northern Michigan is doomed. It is already in the hands of parties who intend to cut and convert it into lumber, shingle and cooperage, as fast as the market demands the same. Visit the office of almost any northern Michigan lumberman and you will find upon the walls a map showing section after section and frequently whole townships and parts of counties belonging to the company. Add these together and you will find that at least 80 per cent of the standing timber of northern Michigan is in their hands. This being the case I can see but little that can be done to save or to greatly extend the time that the present forest growth will be allowed to remain.

Forestry, at least in northern Michigan, must be considered from the point of what can be accomplished in the way of protecting and encouraging a second growth of timber. A large per cent of timber lands of northern Michigan which are being cut over would readily produce a second growth of timber if any means could be devised to stop the ravages of forest fires and it seems to me that this is the proper place to begin and that but little can be accomplished until this is effected. I would have the office of game warden enlarged and dignified by adding to his duties that of fire warden and the care of forest growth. I would have his salary partly paid by the State and partly by the county. I would have his services made effective by all legislation that can be devised whereby he would be enabled to control the starting of fires and the burning of choppings at the proper time, and to restrain the starting of fires at seasons of the year when same would be dangerous and destructive. I would have him bring to justice and account careless fishermen and hunters who frequently cause great damage by their pipes or camp fires. To my mind a game warden who spends days watching some poor settler

to prevent him from catching a mess of trout or shooting a partridge, but pays no attention to camp or other fires left by hunters or fishermen which may result in doing thousands of dollars damage and destroying more game than forty hunters, is very poorly employed and does not understand the first principles of the preservation of game, to say nothing of forests. I would advocate that all reasonable efforts should be made to secure the return to the State of cut lands either by their forfeiture on account of non-payment of taxes or by the voluntary relinquishment of the same by lumbermen after they have been cut over, with the understanding that they are to be withdrawn from the market for a period of twenty-five years, during which time the State will make every reasonable effort to foster a second growth of timber.

A good fire and forest warden could be of great assistance to the Auditor General and to the State Land Commissioner in the selection and care of these lands. Whenever cut lands are bid in to the State for taxes, the Auditor General could have the same examined and if found suitable for the repropagation of timber they could be entered as reserved forest lands and the supervisor notified that the same should not be assessed for taxes in the future. The original owner might be given a reasonable time in which to redeem said lands, but all expenses the State may have incurred in attempting to improve the same should be added to amount of taxes that may have accrued against the lands. As to varieties of timber, nature will have to make the choice in most instances. Some of the best lands will grow up to maple, elm and basswood. The poorer lands to oak, poplar and cherry, in some cases a second growth of pine with cedar and tamarack in swamps. I would not advocate the setting out of timber until we have demonstrated our ability to protect the natural growth. As far as climatic influences are concerned I would as soon have a growth of poplar or some other poor variety of timber, and I am not sure but what it would be preferred to any valuable variety, valuable for lumber products, would cause it to be seized upon at the earliest possible moment that it was considered large enough to make a board, while the less

valuable timber might be allowed to remain to shade and protect the surface of the ground.

The timber of southern Michigan was cut under entirely different conditions from that of northern Michigan. There it was largely cut by farmers who wanted the land for agricultural purposes. Every farmer left a wood lot, a grove or a sugar orchard. Clumps or individual trees were allowed to grow about the premises. Trees were set along boundary lines or road sides. All of which have their climatic influences, but in northern Michigan timber is cut by the square mile, a large amount of refuse is left standing and lying upon the ground and it is then abandoned. The result is repeated fires in times of drought, burning up the soil itself and destroying young forest growth for years. That northern Michigan will grow a second crop of timber has been demonstrated, from 1860 to 1875 the lake steamers all burned wood and purchased the same along the shore of Lake Michigan, from Northport to Frankfort, including the Manitou Islands. This demand for wood caused considerable tracts of timber in the vicinity of Frankfort, Glen Arbor, Leland and Northport, to be cut over clean, and the lands so cut that have not been converted into farms have produced a second growth of trees from six to twelve inches in diameter. This timber usually stands very thick upon the ground and although not as tall as the original timber is already attracting the attention of lumbermen as "most big enough to cut again."

Now to recapitulate:

1. When lands are cut they should be cut clean.
2. They should be burned over in May under the supervision of a fire warden.
3. The title of these lands should pass to the State.
4. They should be withdrawn from the market for at least twenty-five years.
5. These lands should be given judicious care to guard against fire and trespass.

If something can be done to carry out these provisions nine-tenths of the cut lands of northern Michigan would be covered before the expiration of twenty-five years with a respectable second growth of timber.

FOREST ECONOMY.

HENRY M. MELCHERS.

I.—TIMBER SUPPLY.

John Crombie Brown, in the introduction to his exhaustive work on modern forest economy, says: "In the United States of America and in Canada there have been effected extensive clearings of forest lands, resulting in injurious effects upon the climate and a greatly diminished supply of timber, with no prospect of this being compensated by the subsequent growth of trees in the localities. Trees deemed suitable for some purpose desired have been felled, others around them have been left standing or have been cut down to allow of the felled timber being brought out and the results have been destructive in the highest degree, as may be seen in what were once the forest lands in the colony of the Cape of Good Hope, and in Europe, they may be seen in northern Russia."

Gen. James Brisbin (U. S. Army), in his book on trees and tree planting, writes: "The wastes of timber still goes steadily on especially in the Western States; and each year increasing as the forests diminish. Forests are felled, and a man cuts down a tree that his own life time, and that of all his children added together could not reproduce; yet he thinks no more of his act of vandalism than he would if he were removing a stone, a brier, or a dirt pile." If these individual acts of vandalism were all we had to contend with we might rest easy; but every year great companies with ponderous mills go to the heart of our forests, and fell thousands of trees that have been hundreds of years growing. One firm alone in the Western States runs 200 saws. No less than 1,030,000,000 feet of lumber were cut in a single year in the State of Wisconsin. The fires and the saw mills will soon do the work, and America will become a treeless region. "What difference will it make?" ask the careless! A great deal! for with the destruction of

timber goes away much of the usefulness of the country. Did you ever see a treeless land, or have you ever read about one? If not, ask travelers and read carefully the histories of the Roman Empire, Syria, Persia, Asia Minor, and portions of Italy. All these regions were once timbered countries and richly productive, now they are horrible deserts, seamed with ravines and gullies, piled with ridges of sand utterly incapable of reproducing the wood which once covered them. Some years ago to build 71,000 miles of railroad required 184,600,000 ties. Ties have to be replaced about every six years at an average, and it is fair to set down the number of ties required annually at nearly 100,000,000 ties. As everyone knows, railroad ties are cut from young timber, the trees being from 8 to 20 inches in diameter, and this demand strikes at the very source of our timber supply. Again, it is a fact that the fences of the United States have cost more than the land, and they are today the most valuable class of property in the United States except buildings, railroads and real estate in cities. To keep up the fences requires annually an enormous sum of money and consumption of timber. To repair and keep in good order the fences of the State of Kentucky costs $10,000,000 annually, says Gen. James Brisbin, and Illinois has $200,000,000 invested in fences. The whole value of fences in the United States may be set down at over $2,000,000,000 and it costs $1,000,000 annually to keep them in repair. This, I believe is of great political import, when we consider the amount of dead capital which is tied up in fences. The lumber brought to Chicago in 1881 exceeded 2,000,000,000 feet; one train of cars over 1,000 miles long. No less than 300 square miles of land was stripped in the year 1887 to supply the Chicago market with lumber.

Every year we denude 8,000,000 acres of trees and plant less than 1,000,000 acres to replace them. "The end is so plain even a fool may read it is he runs," says Brisbin. According to Dr. Liburnan one acre of cultivated beech woods under favorable circumstances will produce from 5,300 to 6,200 pounds of air dry wood material in one year, both above and under ground, leaves included; but the leaves alone will

amount to fully 3,500 pounds. This would give less than 600 feet, board measure, of wood material, all waste included and approximately from 250 to 300 feet, board measure, of merchantable lumber for the market. Observations made by the forestry department of our government, show that our virgin forests yield at an average of 14 cubic feet per acre per annum (Yearly increase in growth). Our present consumption is about 25,000,000,000 cubic feet per year, or about 350 cubic feet per capita. Our forests amount to less than 500,000,000 acres. Therefore we consume at an average of 50 cubic feet per acre, which would give the following ratio: Consumption: Production per acre as 50:14. In other words we not only consume by far more than we produce by growth, but are cutting into our capital at the rate of 70 per cent of our consumption; and this ratio must necessarily increase under present conditions, each year. This fact alone would suggest the absolute necessity of rational forest economy in our country.

II.—ECONOMIC RELATIONS OF FORESTS TO RAINFALL.

If we desire to fully understand the effect a woodland has upon the climate of a locality it is obviously necessary that we first know what climate is, and to what extent it is dependent upon other forces or natural causes; for instance: The two-fold motion of our globe in space. The distribution of land and water, the winds, etc. Knowing these we can readily decide what influence the forest has upon climate in general. The shortness of this paper will not, however, admit of a scientific discussion of the natural causes cited above, which the author will reserve for a future meeting.

We understand by climate the atmospheric conditions of a given region, taken as a whole, that is, firstly, the presence of heat derived at present almost exclusively from the sun and dependent on its relative position to that of the earth; secondly, the humidity of the atmosphere upon which depend the different forms of water precipitation, and, thirdly, the movements of the air, that is, the character and force of the winds, as also other general or local causes of minor import. It is

our desire to find, if possible, what relation the forests bear to these three general conditions which make up the climate of a locality.

We are all well informed as to the source of light and heat, but not as to the source and amount of atmospheric water. The prevalent idea is that the source of atmospheric water is confined to our earth's surface, being foremost the ocean and its tributaries, but the fact is, that the oceans are a direct result of atmospheric vapors, which at some time of the earth's history were brought to a condensation. Says Winchell in his book entitled "World Life and Comparative Geology," on the cooling of the planet: "The continued progress of cooling effects, sooner or later, the transfer of the body of water from the atmosphere to the planetary surface." The oceans, therefore, are a direct result of the cooling of our planet, and at no time in its history has our atmosphere been devoid of moisture, although varying greatly in degree. Thus we see that a portion of the atmospheric vapor has never been brought to a condensation, and this leads us to the fact, that we must distinguish between the constant and the variable constituents of the atmospheric water; in other words, the constant water supply and the variable or circulatory water supply. The latter was primarily taken from the former and is continually replenishing and withdrawing from it consecutively by the process of evaporation and liquidation.

Gen. A. W. Greely, in his book on "American Weather," writes as follows: "The question of the influence of vegetation and forests upon rainfall is a vexed one, and from its character is not susceptible of positive proof or disproof. The influence of forests on rainfall or temperature must depend on the extent, density and character of the woodland growth. The evaporating and absortive powers of foliage vary with the species and are also dependent for nearly all the year on the amount of persistent leaves." To my mind there is no question but that the presence of vegetation subserves the conservation of rainfall and aids in its regular and systematic distribution. The effect of trees upon the rainfall of a country is no longer disputed by the intelligent, says Gen. James Brisbin.

The amount of precipitation is increased in some sections to no inconsiderable extent by deposition in the form of dew upon the growing vegetation. Since the precipitation of a country is increased by the deposition of dew, and as the vegetation absorbs the moisture instead of allowing it to pour into adjacent river beds in rapid torrents, it necessarily follows that local evaporation is by this means increased. While the amount of increase may be small in some cases yet it must be considerable in others.

Blanford has pointed out, that in India the rainfall in some sections is fed to no considerable extent by local evaporation. As regards the influence of forests, *Woiekoff* has pointed out that they assist in storing the water by protecting the soil, and thus maintaining constant evaporation, and that the forests materially modify the wind movements, thus preventing the transference of evaporated vapor to other points, while also tending to induce calms, which are so favorable to ascending currents and local precipitation. Fortunately for elucidation of this question the fire-devasted forests of the central provinces of India have within the past fifteen or twenty years been replaced by extensive growths of young forests covering 54,000 square miles.

Twenty-two rainfall stations are maintained over this area, with records covering the past twenty-five years.

It appears from these observations that the rainfall for this province has progressively increased with the growth of the forests, and apparently is twenty per cent larger than the average for ten previous years. Observations in a forest in the Punjab covering 17,000 acres indicate by a register within the forest, an excess of six per cent over the probable rainfall register of two stations respectively four and thirteen miles distant from the forest. The experiment is being tried in Nebraska with encouraging results, as the rainfall is gradually increasing. Liburnan, Ebermayer, Brisbin, Hough, Blanford, Greely, and many others take the same view on this question, and in fact, Greely says "the long suspected influence of forests upon rainfall is no longer a question of equally balanced probabilities."

Unfortunately there are no such statistics available in the United States, but Gen. Greely believes that the extensive cultivation of the soil and the development of the western territories has increased in some degree the rainfall west of the Mississippi river through the medium of largely increased vegetation, and through the enormous increase of scrub growth and fruit trees.

In Ceylon all jungle land above 5,000 feet is held by the government, who refuses to sell it at any price, on the ground that were the jungle to be cleared off it would tend to greatly reduce the rainfall.

Rains are caused by a condensation of moisture from cooling below the dew point. The success of forest growth depends largely upon their amount, and their seasonable distribution throughout the year, and especially their occurrence when vegetation is most active and when the new layer of wood for the season is forming. In a dry time we sometimes see filaments of rain descending from a cloud, which dry up and disappear in the warm air below without reaching the ground.

When such clouds pass over large bodies of woodland, where the temperature is cooler and the air more moist, these filaments extend down and afford a shower of rain, but dry up again when they come to the warm air of the fields beyond. Applying these principles of humidity and temperature to forestry, let us consider what effect a woodland can have upon them. In the growing season there is a vast amount of evaporation going on from the foliage of trees, the moisture being derived from the soil. This evaporation is a cooling process, and as it both increases the amount of moisture while it reduces the temperature, it tends to bring the air to the dew point, in other words to the condition favoring the formation of dew and rain. In the nicely balanced state of the atmosphere that we often find in summer this change may sometimes be the turning point that decides between rain and drouth. It has been found many times that when the trees and bushes are cleared away from large areas of rocky surface

the region begins to suffer from drouth. The rocks being heated by the sun remain warm in the night, and the rain clouds which, in passing over the wooded surface formerly condensed in gentle storms now dry up in coming to the heated air, and perhaps yield a copious rainfall over a better wooded district beyond. These effects are more apparent when the clearings have been extended over considerable areas, and they could with certainty be overcome by allowing the rocks to be again clothed with a growth of trees. The effects of woodlands upon the rain that falls upon them may next be considered. Admitting that the amount of rain that falls upon the woods is the same as that in adjacent fields it is evident that a part would be interrupted by the foliage, and in transit showers be evaporated from it without reaching the ground. But the air within the woods is always more humid in the growing season, and the surface is always shaded from the sun and sheltered from the winds. It sinks into the ground instead of running off on the surface; it cannot wear away the soil upon steep slopes, nor form sudden and destructive floods, as in a naked and treeless region. The streams rising in a woodland may swell after a rain, but more gradually, and they will subside again more slowly. Springs and wells in a wooded region have a much more uniform supply of water than in the same region when cleared. Instances have often been observed where these become dry upon clearing, and again well supplied with water as before, when a forest growth was restored These principles become important when applied to the supply of water for cities and towns, and for maintenance of water in canals or for hydraulic power. The basins of supply should, if possible, be kept wooded, and rivulets kept shaded. In Illinois and some other prairie states there has been observed a noticeable increase in the dryness of the climate since settlement first began. This may in part be attributed to the clearing away of the belts of native timber along the streams. The beds of these streams are now lower, and they drain off the water to a greater depth. The effect is shown in the failure of water in the wells and in the

more frequent occurrence of drouth, to the injury of agriculture.

The evaporation of the earth through trees is immense. A good sized peach tree will give off eighteen pounds, or about two gallons of moisture every twelve hours. The roots of trees often draw moisture from springs themselves.

Those who have watched the effect of forests on rainfall say, that by commencing at the edge of any dry belt, the forest and consequent rainfall may gradually be extended across the whole of the dry belt. No state in the Union has done more to replace her forests than Nebraska, and is already reaping the rewards of her generous labor in behalf of the trees. At a depth of some twenty feet from the surface of the earth white sand is struck in both Kansas and Nebraska which is full of water, and in some places forms subterranean streams. This makes both these states famous forest growing regions, as the roots of the trees readily seek the moist, white sand, and the trees grow with a rapidity which is perfectly astonishing. In time, as Nebraska increases her forests, the rains will become more frequent, and some day, should she persist in her present system of tree planting, she will be as well watered as Iowa, Illinois, Wisconsin, or states further east. The river Elbe has lost eighteen per cent of its flow in consequence of cutting away the trees along its banks, exposing its waters to the hot sun.

Electricity is also a great agent, the trees being negatively charged, and drawing with great power the positively charged clouds. This theory is no longer a matter of doubt or experiment, but a fact demonstrated by experience and a knowledge of the laws that govern the atmosphere.

III.—ECONOMIC RELATION OF FOREST TO DESERT WINDS.

The Pacific coast is noted for its cool and equable summer temperature; but instances of desert winds have been known in California quite often, which seriously affected vegetation and animals, and incurred great loss. The most remarkable of these desert winds swept over middle and southern California on June 17, 1859. In San Francisco the thermometer

registered from 77 degrees to 133 degrees in the short space of one hour. It was a burning northwest wind, and lasted only a few hours. Santa Barbara was affected at the same time, and registered about the same temperatures. This American "Sirocco" caused a great deal of damage, all fruit being destroyed, and calves, rabbits and birds were killed by the hundreds. The frequency and intensity of such visitations have diminished remarkably since 1859.

Prior to that date thirteen heated terms yearly at an average had visited California. Since then up to 1871 only four heated terms at an average yearly have been recorded. The immense quantity of land placed under irrigation and the vast increase of vegetation are obvious reasons why there should be such marked diminution in this respect, writes Gen. A. W. Greely in his book on American weather.

Other examples might be cited. For instance, Lower Egypt, Colorado Desert, and cities in the United States. I would refer you to Greely's book on American Weather. This illustrates the importance of preserving such natural conditions as will render heated terms difficult and serve to modify their existing conditions, and in no way can this be better done than by cultivation and conservation of growing vegetation, and especially of woodland and forest.

IV.—PRESERVATION OF FORESTS.

More than two hundred years ago France was in danger of being entirely devastated by the system of "jardinage" in the exploration of forests, and there was issued an ordinance requiring that crown forests should be divided into a specified number of sections, one only of which should be exploited at a time, so as to allow time for the trees to be reproduced in each, before all the others had been exploited in succession. This measure was hailed as one likely to succeed, but less than one hundred and fifty years sufficed to show that this was a vain hope, for the reproduced forests were not equal to those that had been felled.

Early in the present century there was devised in Saxony a more complicated but a much more efficient method of

exploitation. Every tract of timber land is carefully surveyed, and treated on a working plan made with great exactness, as to actual details and expected growth. Care is always taken that in high forests there is a good stock of self-sown trees before the old crop is entirely removed.[5] Systematic observation and experiments are made as to the rate of growth, and the best soil for each description of tree, and led to an establishment of an admirable system of forest cultivation, as carefully conducted as field tillage.[5]

This method is being adopted everywhere on the continent of Europe.[4] It has been introduced with satisfactory results into the management of forests in India and Australia,[4] and the adoption of it seems to be the only means available to prevent the ruin of forests in our country, which are now being rapidly destroyed.

The author is indebted to the works of Brown on Modern Forest Economy, Brisbin on Trees and Tree Planting, Tratman Government Report on Forestry, Liburnan, Wald-Kliman. ũ Wasser, Greeley on American Weather, and Hough on the Elements of Forestry for many of the statements of facts herein given.

FORESTRY.

CHARLES HOLMES.

To the Michigan Engineering Society:

GENTLEMEN—While your committee on forestry has been requested to consider but two branches of a very comprehensive subject, viz.: "The climatic effect of the removal of forests and plans for preserving the same," we realize the necessity of making a wide collection of facts, and the difficulty of properly grouping them, so as to present them in the limits of a report, intelligently, to this society.

It is well known that the numerous subjects comprehended under the name of forestry covers a large field; that the literature of the subject of forestry is a large one, and that it is growing at a rapid rate.

The popular belief in forest influences has been founded largely upon the observations made throughout the world by the older writers on the subject. The conclusions drawn from these observations—which is known as the historical method of discussing the subject—are not accepted by present day scientific investigators. But the scientific method, as at present applied, has not yet reached a final solution of the question of forest influences upon climate.

For ourselves, we regard much that has been recorded by the old writers as worthy of credence, and leaving out of account their pictorial and sentimental conclusions regarding forest influences, our own observations, covering a period of fifty years, compel us to accept their more rational and conservative opinions. Until it is shown beyond all doubt to the contrary, we must hold that the ruthless exterminator of forests modifies not only the productive character, but the climatic condition, of wide ranges of country. We learn from the study of forestry, that man's influence on forest vegetation, either as a destroyer or restorer, is so great that he can produce a more marked, visible, widespread and permanent

change on the face of the earth he inhabits than he can effect in any other manner; and that it is altogether within his power, with the aid of a little time, to change the climate of a country.

Dr. Hooker, an eminent authority, in 1873 said, that "it is principally on climatic considerations that the cutting down of forests seems to require government supervision * * * I have lately received an account of the deterioration of the climate of some of the Leeward islands, which affords a melancholy confirmation of what I have urged above. The contrast between neighboring islands is most striking. The sad change which has befallen the smaller ones is, without any doubt, to be ascribed to human agency alone. It is recorded of these that in former times they were clothed with dense forests, and their oldest inhabitants remembered when the rains were abundant in the hills and all uncultivated places were sheltered by dense groves. The removal of the trees was certainly the cause of the present evil."

Mr. Hough, president of the United States Association for the advancement of science in 1871, writes of the distress of India from famine, thus: "From a careful study of this subject, with such data as are accessible in late reports, we cannot doubt that this calamity is largely due to the fact that the forests have, within recent years, been swept off by the demands for railroad and other uses much more rapidly than formerly, and that the exposure to winds and sun, thus occasioned, may have largely contributed to these painful results."

"The Island of Curacoa was," again says Mr. Hough, "within the memory of living persons a garden of fertility, but now whole plantations, with their once beautiful villas and terraced gardens, are nothing but an arid waste; and yet, sixty miles away, along the Spanish main, the rankest vegetation covers the hills, and the burdened clouds shower down abundant blessings."

In eastern Ohio, William C. Bryant, not long since, gives evidence that "it is a common observation that the summers are becoming drier, and the streams smaller, several rivers showing a considerable decrease in navigability during the

last fifty years. The summers are hotter and the winters are colder." This is referred to the destruction of the forests along the tributaries of the Mississippi.

The changed condition of the climate and the inexorable lowering of the rivers of our once beautiful peninsula of Michigan is clearly due to deforestation; and the low water of our rivers has become an important element, with which we have to reckon, in planning for water power or water supply.

We think that the evidence is conclusive, that the destruction or undue removal of forests in many parts of the new world as well as of the old, has a marked local and prejudicial effect on climate; and that the desolation which has been brought on the former homes of teeming human life in the countries of antiquity is attributable to the same cause. Babylon and Nineveh, Thebes, Memphis and Carthage, now waste and even pestilential, were formerly the very hives of human life. So thorough has been, not only the change of climate, but the denudation of the soil, caused by the cutting down of the olives, palms, and other trees of Palestine during the Roman war, that the former fertility and beauty of that interesting country, of which we have abundant record, has largely disappeared and the country east of the Jordan turned into a desert.

The effect which the clearing of forests exerts upon rainfall is most conspicuous and which in turn produces unfavorable climatic conditions. The United States Commissioner of Agriculture for 1871 reports: "In Upper Egypt the rains, which eighty years ago were abundant, have ceased since the Arabs cut down the trees along the valley of the Nile towards Lybia and Arabia. A contrary effect has been produced in Lower Egypt, from the extensive planting of the Pacha."

Valencia, in South America, it is said, was formerly "situated about one mile and a half from a beautiful lake, which was surrounded by a dense forest. The trees were cut away, and in the course of time the waters receded to the distance of four miles and a half. The trees were afterwards replaced by others; and in about twenty-two years the lake returned to its original boundaries."

The history of the forests of France would alone be sufficient to show the consequences of the destruction of forests. "By the destruction in France of a great extent of forests," writes Dr. Brown, "in order to replace them with cultivated fields, the temperature has become very irregular; heavy rains, storms, and dryness have each done their work upon the soil, and made crops every year more and more uncertain." In the Vosges, the destruction of forests has gone so far that agriculture has suffered, the soil has become arid, and inundations are frequent. In the Department of the Gard, in 1837, "no rain fell for nine months." Nismes, named from the forests which once surrounded it, is now amid an arid waste. At Beziers, the agricultural society reported in 1797 that the forest which once sheltered the place having been destroyed, the loss of the olive crop was the consequence. The authorities of the Isère represented, in 1793, that the destruction of the forests had altered the temperature, augmented dryness, and seriously affected the crops. From Provence, from the valley of the Moselle, from that of the Haute Garonne, from Hèrault, and from the eastern Pyrenees, come complaints of the same nature. The regular rainfall has been diminished, the temperature has changed and become uncertain, and partial and irregular storms have proved curses rather than blessings, wherever the forests have been ruthlessly swept away.

History supplies us with many confirmations of the statement we have made to the effect that the destruction of forests has a marked and prejudicial effect on climate.

In turning to the next branch of our subject, we have reviewed some of the questions relating to forestry, and some of the salient features of forest management, as it is the sense of your committee that in the absence of such review, any plan proposed for the preservation of forests would be lacking in force and without value to this society.

From a perusal of public documents, and the reports of public land commissions to the government of timber bearing countries; also other volumes pertaining to forestry your committee is forced to the conclusion that the destruction of accessible forests is in full career throughout the world, that

the progress of the planter is slow, feeble, and ineffective, while that of the desolater is rapid and widespread. At the rate at which the destruction is proceeding in the United States, a very few years will suffice for the purpose of complete denudation. In Michigan, we think, it is already too late to adopt measures for the preservation of evergreen forests, and observations show that the desiduous forests are fast dropping before the lumberman's ax and devastating fires. The deforestation of large areas of this State is already seriously crippling some of its industrial centers; and many a broad acre is lying waste which has no agricultural value and is suitable only for timber culture.

The great economic value of the products of forestry is unquestioned. So, likewise, is the absolute necessity of forest products, as the material for, and very mainspring of, other industries, and as vital to our civilization. Still, the subject of forestry is receiving inadequate attention in most of the forest bearing countries of the world. In some it is utterly neglected. Germany and France seem to be the most advanced in the theory and practice of forestry, and in India and New Zealand, of late years, the conservation, planting and management of forests has received much attention. Timber culture in the United States under the several acts of congress from March 3, 1873, to June 30, 1882, has not been a success. Reports show that, between the above dates, "individual entries were made under this law, containing 13,657,146 acres, an area almost equal to the total surface of the states of New Hampshire, Massachusetts, Rhode Island and Delaware. During this time but 165 entries have been consummated, containing 23,571 acres."

"This act has been denounced by officers charged with its execution and by special examiners, as one generally used for the benefit of fraudulent enterers and grabbers. Its practical utility is questionable and thus far it has been used mostly by speculators intent on acquiring large tracts of public lands. This law, in practice, is not for the real benefit of the actual settler or the nation."

The report of 1888 shows that the lands taken up under

these acts equal 40,000,000 acres, and 650,000 acres finally entered.

Some writers urge the necessity of State control of all forests, on the ground that no private individual, or corporation, could be expected to let their wood grow long enough to furnish timber of a size fit for its several uses; and many are agreed that legislation is universally needed to regulate the manner and the extent of cutting out of forests, as a means of prolonging their usefulness and preventing wanton waste. We think that the need of the hour is a few patriotic statesmen to plead for the preservation of forests, the greatest natural blessing of his country; but we are not without hope that they are forthcoming.

The greatest need in this State, at present, is restoration or replanting forest areas. The preservation of forests implies forest management, and successful management requires the service of the skilled forester. The aim of scientific forestry, in its present most advanced state, is to convert the regular growth of a woodland district into a compact forest; divided into distinct blocks of trees of equal age. The usual rotation for beech, or high forest, in Hanover, which may be taken as the model state, is 120 years. The forest is so divided that there shall be as nearly as possible six equal areas allotted to as many periods of twenty years' growth. Thus one block will be full of trees not exceeding twenty years old; a second of trees from twenty to forty years old, and so on. When a block arrives at its last period, felling commences by a preliminary clearing, which is little more than the ordinary thinning carried on from time to time in former periods. The beech in these woods only ripens its seed every third or fourth year. After the first seed year in the final period, a clearing for light takes place, in order to afford light for the germination of young seedlings, the finest trees being left standing. When the ground is well covered with seedlings, the old trees are felled and carefully removed, and the block recommences growth. The tendency to a gradual removal of the old trees appears to be on the increase, so as to make the culture

approach as nearly as possible to the natural growth of a wild forest.

The staff for the administration of forests in Hanover consists of two branches, which may be described as preparatory and administrative. All preliminary arrangements, on taking a piece of forest land into culture by the state, are conducted by the Survey Office. This consists of a superintendent, draughtsmen and clerks, who are generally practical foresters; and a staff of surveyors and valuers who are generally candidates for the office of overforester, the third grade in the system of permanent administration. The surveyor surveys the whole tract of forest, and delineates, with the aid of the valuator, the blocks or subdivisions into which it is to be divided for permanent culture. A detailed plan is drawn up for the future management, pointing out the mode in which the successive periods are to be worked off, the roads which it will become necessary to make for transport, and the usual details of the condition of the forest. This plan, together with a complete code of rules, is handed over for the guidance of the permanent forest officers.

The permanent administration consists of one forest director, and overforestmaster, who is also a counselor; twenty forest masters in charge of circles or divisions, who form also a consultative council; 112 overforesters, in charge of districts of about 17,000 acres each; 403 foresters; and 343 overforesters, and underforesters, who watch the forests and supervise the work executed by contract or by day labor.

Forestry, in the countries of continental Europe, holds an honorable and distinguished place amongst the branches of a liberal education; and travelers speak with admiration of the extent and variety of the studies required from forest probationers in Prussia. In England a regular education for the duties of the forester is neglected, and all candidates for forest appointments in her colonies were, but a few years since, sent to France and Germany for instruction.

The actual yield of those forests which are in course of systematic culture and working in Europe varies to a great extent. The reports before us state that in France there yet

exist 2,700,000 acres of state forest, in the conservation and management of which $2,500,000 is annually expended; the returns amounting to $8,700,000. Another statement of forest statistics is tabulated as follows:

Name of State.	Area of State Forests in English Acres.		Yield of Column 2.
	Productive.	Non Productive.	Cubic Feet per Acre.
1.	2.	3.	4.
Prussia	5,836,100	666,175	34.5
Saxony	378,555	15,614	72.5
Bavaria	2,079,835	238,738	63.0
Würtemberg	469,087		84.7
Baden	212,770	18,817	80.6
Austrian Empire	1,576,699	653,347	41.0

The park like forests and woodlands of England, which are unsurpassed for picturesque beauty and historical association, according to a return to the House of Commons, are 12 in number, and have an area of 112,376 acres, of which 51,606 were actually under wood. Of these the New Forest, with a woodland of 22,319 acres, had a revenue, for one year, of $60,170 and an expenditure of $38,950. Dean Forest, with 14,754 acres under wood, earned $54,190, at a cost of $39,390. High Forest Meadow Wood, purchased in the reign of George III. for the growth of oak and fir, contains 3,359 acres. The revenue in one year was $25,880, the expenditure only $9,135. Thus the financial outcome is better than might be expected from the absence of regular education for duties of the forester. The net revenue of the Bavarian forests is stated at 2 1-6 dollars per acre, and that of the Saxon forests at 3 1-8 dollars per acre, but in Prussia and Austria the profit to the state is far less.

It is not very easy, it is not always possible to renew extinct forests, and government planting, as a method of restoring exhausted forests has, in some instances, resulted in failure. Under some circumstances planting can be resorted to with success; but the general outcome of forest experience is to the

effect that the systematic care of self-sown seedlings, and the thinning of the young growth, year by year according to definite plans, is the true method of providing for forest reproduction.

Some years ago, when the British government were made aware of the destruction which had been allowed to take place in the teak forests of India, and purchased 260 square miles of forest land for planting young teak, several plantations were attempted, but it was found that the expense of planting an acre with teak was greater than the value of the timber likely to be produced, after 100 years, on a square mile! Again we find that, in 1842, the same government laid out several plantations of teak in Burmah. The teak was found to grow freely from seed; but so little care was taken of the seedlings that in 1845 only one tree was found alive. It was, however, in British India that the most brilliant triumph yet achieved, was by the skill of the forester, in the naturalization of the precious cinchona. There, on the hill sides and slopes of the mountains the cinchona grows luxuriously in the government plantations and returns a handsome income.

Individual effort has not always been successful in the direction of scientific arboriculture or planting. 'Fifty years ago the Danish island of Santa Cruz was described as "a garden of freshness, beauty and fertility, woods covered the hills, trees were everywhere abundant, and rains profuse and frequent." Twenty-five years later one-third part of it was reduced to an utter desert. An attempt to restore the former fertility by means of planting was made too late. One planter had set a thousand trees, but every one of them failed.

The contrast presented between Japan and the countries of the Western World, in respect to the treatment of forests, is a striking feature of this interesting and all important subject. But whether their methods are the result of the promptings of good practical sense, or veneration for the ancient laws of certain races which prohibit the wanton destruction of fruitful trees, they are none the less worthy of emulation. To quote Commodore Perry: "The most common forest trees are the

fir and the cypress, and so sensible are the Japanese of the necessity of preserving their timber trees, that neither of those above named can be cut but by permission of the local magistrate; and the law requires that for every full grown tree that is felled a young one must be planted." Sad as it is to own it, it cannot be denied, that Japan is far more worthy copying than we are; and we hope that in her present eagerness to Americanize herself she will be wise enough, in her effort at rapid results, to abstain from the destruction of her forests; and not follow the hustling Westerner, who is forever seeking to hasten the acquisition of the golden eggs.

In New Zealand vigorous measures have been taken against forest-arson, and the wasteful cutting out of forests. According to Dr. Hooker, in the year 1830, out of a total area of 66,000,000 of acres, contained in New Zealand, 20,000,000 in round numbers were under forest. In 1868 the forest area had sunk to 15,000,000 of acres; in 1873 to 12,000,000. At this rate the entire woodland of New Zealand would have been destroyed by the year 1893. In 1874 it was considered the function of the state to adopt measures for the conservation, planting and management of the remaining state forests through state agency.

We share a common belief, based on available forest statistics, that the rate at which the forests of the United States are being laid waste is so rapid, and the inducement to continue that waste is so great, that fifty years will suffice to destroy the remaining forests. A small library of laws have been passed in the states and territories from an early period, designed to prevent indiscriminate cutting of timber and to prohibit the unauthorized cutting or injury of timber, but they have all proved more or less ineffective. The American Forestry Congress was formed in the year 1882 for the purpose of arousing public interest in forestry and to encourage every means designed for the protection and preservation of forests. The establishment of Arbor Day, by law, in several states of the Union, has been the means of diffusing some information, through the country, on the subject of Forestry. It has also been the means of directing public attention to the

facts relating to tree planting, and the practical use of trees. It has not been attended by any great results; while the impulsive work of devastation goes on apace!

Thus we find that the agencies in force in this country, which require individual effort, to preserve and perpetuate our forests are very inadequate when we consider the magnitude and importance of the subject; even if it devolves as a special duty on the individual? We think that at the rate at which the depletion of our forests is going on, that absolute obligation is incumbent on the law making body of this great nation to use its power, in a reasonable and constitutional way, to prevent further indiscriminate cutting down of forests.

Considering the incalculable amount of national advantage that must result from a wise disposal and skillful management of the vast forest property of the United States, as yet undestroyed, our legislators should be urged to keep the control of remaining forest land in the hands of our government.

On December 4, 1896, two or three days after the foregoing paragraphs were written, the annual report of the Secretary of the Interior was made public. He advises "that no permits to cut timber on public lands should be granted for any purpose other than to supply the needs of actual settlers in the neighborhood of the forests where timber is to be cut, and should be accompanied by all possible safeguards. Lands are being taken up so rapidly that if the rate of the last thirteen is continued for the next thirteen years there will be little of the public domain outside of Alaska in possession of the government at the expiration of that time."

It is thus that the present seems to be a fitting time to call attention to the need of an intelligent and efficient legislation on the subject of Forestry; and whilst it may not be within the province of Engineering Societies to formulate such legislation, they can, perhaps, do much towards paving the way to it.

THE STUMP LANDS OF NORTHERN MICHIGAN, AND WHAT TO DO WITH THEM.

A. J. TEED.

Lands generally called stump lands in the northern part of this State may be divided into two classes:

First.—Those lands where the original growth of timber was mostly hardwood, and the soil is sufficiently fertile to make them profitable for agricultural purposes. These lands will all be taken up and made into farms; and therefore so far as this paper is concerned will not be considered.

Second.—Those lands where the original growth of timber was mostly pine. As to these lands, the timber has been cut off or destroyed by fires, the soil is more or less barren and the land is lying idle and waste. The question now is, can these waste lands be put to any profitable use, or must they lie forever idle, silent and sad, like tombstones set up to commemorate the glory of the once magnificent forests of Michigan?

Certainly they cannot be made into farms. Many people have bought some of these lands, and settled on them because they could get them cheap, but the longer they live on them the poorer they get, and in some cases the settlers on these barren pine lands get so very poor that the only way they can get off is to die off. Owing to the severity of the climate only a small part of these lands can ever be made profitable for fruit culture.

It has been suggested that they might be utilized for pasture. In dry seasons these lands will produce very little grass, and in wet seasons there is pasture enough in the swamps and on the better lands for all the stock the country is capable of carrying through the winters.

It seems to me that the only practicable use to which these lands can be put is to produce on them another growth of timber. They have grown timber once, why should they not be made to grow timber again?

But would it be practicable to grow another forest? There

are certainly difficulties in the way. First, it takes a long time for a forest to grow. Second, on account of fires and other causes it is difficult to get the trees started. The reason the trees do not grow of themselves is because the forest fires have burned up the seeds. But how long would it take to grow a pine forest? I have seen it stated by some of the wise newspapers of this State that it would require from 100 to 150 years to grow pine trees large enough to be of much value. It is true that many of our cork pines were from 150 to 250 years old, but these same trees have ceased to grow for years, many of them would have been better for timber 50 or 100 years ago than when cut. A young, thrifty pine forest has more value per acre than do these antiquated, dead-at-the-top and rotten-at-the-butt cork pine. On the other hand some of our optimistic editors are claiming that valuable pine trees can be grown in from 15 to 20 years, and in support of this it is shown that some of the pine forests that are now being lumbered off in the South have grown up since the war. But where I live there are lots of pine trees growing that I know are more than 10 years old and are not large enough yet to make a respectable Christmas tree. In my opinion to grow a merchantable pine forest in northern Michigan would require from 30 to 50 years, and I think that time would do it. I have no definite data of what it would cost to plant the seeds and protect the trees till such time as they should be large enough to care for themselves, but it would certainly be a considerable sum.

Now, who can afford to plant and care for the trees and then wait 30 to 50 years for them to grow. No person of small means could do it, and men of wealth are not likely to invest large sums of money where they themselves cannot expect to live long enough to receive any returns from it, and where the interest on the investment and the taxes would make it uncertain whether it would even be a good investment for their children. If, then, a new forest is ever to be grown on the waste lands of northern Michigan it cannot be done by private parties, it must be undertaken by the State. Men die, but the State lives forever.

But, would it be just for the State to tax the present genera-

tion to grow a forest for the benefit of the next? I think it would. First, we have stripped off and received the benefit of the original forest, would it be more than fair to put something back for the benefit of those that follow? Besides, this generation has not hesitated to issue bonds and make debts for the next generation to pay, would it not be right for us to make some provision by which the next generation might be able to pay these bonds?

But, supposing it is admitted that it would be wise for the State to undertake to grow a forest on these waste lands, how is the State to get title to the land? This is the only real obstacle in the way. To accomplish this result would require some additional legislation. It would be out of the question for the State to undertake to buy the land. But if our tax laws were properly adjusted in a few years most of this land would go into the hands of the State for delinquent taxes. Suppose some such plan as this were adopted. Have the land assessed high, say two to five dollars per acre, and have each piece of land held responsible for its own taxes. If a man did not wish to pay the taxes on this valuation he could let it go to the State, and when the State once got possession of the land the price should be put up so high that no one would be tempted to buy it.

Undoubtedly other and better plans might be suggested. But it is certain that something should be done to redeem these deserts of the north. We would not have to wait 50 years before we would begin to receive a benefit. The immediate effect of a green growing forest on the general aspect of the country and on the climate would go far towards compensating the State for the expense incurred. It would cover up the sand and the stumps and the logs. It would break up the winds in the winter and shade the ground in the summer. It would afford shelter and a hiding place for game, and camping ground for the sportsman. Then could we sing with enthusiasm "Michigan, My Michigan." But now, the weary traveler, shivering with the cold, as he plows his way over miles of bleak and desolate waste, through howling winds and drifting snows, can only moan "Michigan *was* a daisy, but last night she died."

THE PRESIDENT: The papers and report of committee are before you for discussion.

MR. SEARS: I would like to hear from Mr. Hodgman on this subject.

MR. HODGMAN: This subject of forestry is one that I don't know very much about. If I *knew* all the contents of those exhaustive papers I should know a lot more than I do now. I have my doubts in the first place whether all of the claims in regard to the effect of deforestation on climate can be substantiated. I do not believe that the forests or the removal of them have quite so great an effect on rainfall as is sometimes claimed. One thing that makes me doubt it is the condition of the climate the past two years; we had just the same forests year before last as we had last year but we had a great difference in the amount of rainfall. The same is true of different years all over the United States and it is doubtful if the forests have any positive influence one way or the other. There is an idea that will be brought out in a paper to be read in regard to lake levels which shows another cause for the drying up of this country. The amount of rainfall, the height of the streams, and the forests seem to be mutually dependent, one on the other, and what affects one affects the other.

Now as to the rapidity with which the forests can be reproduced, I can say a very little about it. I can remember when I was a lad and went to school we had right close by the schoolhouse a patch of what we called oak grubs, and they were so small that we little fellows used to climb them, bend the tops together and make wigwams of them and play we were Indians. Now those trees are 50 to 75 feet high, and they are from eight inches to two feet in diameter, oak and hickory trees, and look you, they have grown within my remembrance. In our part of the country timber grows rapidly, and if the country was simply left alone when it is cleared and not cultivated, it would be but a little while before we would have new timber.

MR. SEARS: I am very much interested in this talk; I think there is no question of more importance to the public, and I regret that we are not talking to this legislature up here

instead of these small numbers. There is no question but what a forest can be grown and made a source of profit and not take a very long time either. In 1859, in clearing out the right of way for the F. &. P. M., there was a line cut out and then the line was afterwards changed, and on this first line there has a native forest grown up. I sent a reliable man last Saturday to count the trees, and he gave this list: There are 20 cottonwoods ranging from 6 to 20 inches in diameter, in height ranging from 30 to 75 feet; 12 elm ranging from 4 to 12 inches in diameter; black ash, 133 ranging from 5 to 8 inches in diameter; white ash, 102 ranging from 5 to 12 inches in diameter; red oak, 64 ranging from 4 to 12 inches in diameter; poplar, 35 ranging from 6 to 15 inches in diameter; soft maple, 8 from 5 to 12 inches; 2 basswood 6 inches. Now figure a strip 50 feet wide and 700 feet long is about three-fifths of an acre, and pro rate that to get at the number averaging on an acre and we should have 486 trees on one acre. This soil was not very well adapted to the rapid growth of trees, as it was low. If the land had been ditched and cared for these trees would have been once and a half times as large as they are now. I have planted about 1,800 trees myself in different points in Michigan and I never had any trouble with a tree that I planted myself, nearly every one of them lived; but the hired man never seemed to have as good success; when he set them out they died. At one time I had a cottonwood and a locust growing side by side and I measured them weekly, and I could detect the growth in a week; in a month the cottonwood had increased in diameter nearly a quarter of an inch and the locust pretty nearly an eighth of an inch. If I was master in this business, Governor of the State, I would appoint a commission at once and I would take one or two men from this society, and I would send them to Germany and France to learn the methods which have been hinted at here and I would set them to work growing trees. There is nothing of more importance, and the man who won't do something for the future man is no man at all. If a fellow hitches his horse to the nice trees in front of your house, lick him. If ever I catch a man doing it, I will.

MR. APPLETON: When I was a boy, in England, something

like ten or twelve thousand acres were being reclaimed by being planted to trees. The method adopted there was to plant the seed and raise the trees as you would in a nursery. Pine trees and that variety of trees were planted four feet apart each way. Of course they are pretty small trees. In two or three years they go and take every other tree out; that leaves them eight feet each way, and then after that another thinning out leaves a beautiful forest. I remember I was a boy when they were planted, and those trees were planted in just such soil as my friend Teed has told about. Thousands of pounds have been squandered importing all sorts of earth, but the soil is so poor that in the center of those low lands nothing but pine trees will grow there. I was there forty years ago, and I was a boy when those trees were planted, and those trees were 30 or 35 feet high. But what marred the success of those trees was that some people from mischief and some from accident set fires in there and when fire gets into a forest of pine it goes through it like a whirlwind. I set out 38 years ago a basswood in front of my house; I brought it home in my buggy, it was about the size of a whip stock, and it will measure today fifteen inches in diameter. I do very much believe that if there is anything that can be done to this barren land that will pay it is by raising trees in the nursery and transplanting them. Now those trees I spoke of, I can remember when they were not two feet high, and when I left them forty years ago they were up to 30 or 35 feet high. It may be of a little historical interest to know that on that same ground the earthworks are still there that Julius Cæsar used; his fortifications, walls, mounds of earth and so on where his army encamped.

Col. Muenscher: I approve of very much that has been said by this committee, especially in regard to stopping forest fires; that is waste, and all waste of anything that has value is to be deplored. I should be perfectly willing to see the State take all proper measures to prevent these fires, and that is as far as I ever expect the State to go. If we can stop these fires and let nature do the work of reclaiming, it is the best that this generation can do, and nature will be very apt to do it quite as well as we could. At the same time I am inclined

to agree with my brother Hodgman that there are two sides to this question. As to the effect of the forest upon the climate, I am a little afraid we are apt to put the cart before the horse and to take effect for cause. Now, which existed first, the forest or the climate? Has the forest produced the climate or has the climate produced the forest? Is the condition of our western plains in America due to the absence of forests, or is the absence of forests due to the condition of the country? Now in regard to these countries in the east that have become so deteriorated, I am inclined to think there are other causes that have been working there quite as strongly as the removal of the forests. I have seen farms in southern New York and in some of the southern states on which the soil has been completely under cultivation, and on which the red soil lies there baked like clay, and it is cut up with gullies in every direction, almost impossible to cross one of those with a team. Right alongside of that, half a mile away or close by, you will find farms in excellent condition. Now, that is certainly not due to the difference of climate, but to the fact that one farmer has skinned the soil and taken away all the good of it and put nothing back in its place, while his neighbor has restored the fertility as fast as he has removed it. It is not the difference in rainfall, and I am not quite satisfied from what I have seen that the removal of forests has had a very great effect in changing the rainfall. Now, it seems to me that when I was a small boy floods were just as great and more frequent than they are now. Perhaps it is because I looked at it with a boy's eye and the idea of the fun that it was bringing, but it is my impression that I have brought from childhood that floods in Ohio where I was brought up were more frequent and larger than they are now, and that was before the forests were largely removed.

Then there is another thing and that is that the uses of timber for the benefit of mankind are rapidly and largely diminishing. The place of timber is being taken by other materials. When I was a boy I cannot recollect of seeing a bridge that was not made entirely of wood; now you never see one that is made entirely of wood. Steel has taken the

place of timber, and to the benefit of mankind. Who wants to go back to wooden bridges?

MR. SEARS: If the old wooden bridges were taken care of as well, wouldn't they last a good while? They used to cover those wooden bridges and protect them from the elements.

COL. MUENSCHER: That is the reason they lasted so long. The railroad ties, the wooden ties, are fast being supplemented by steel. The time will come—perhaps we will not live to see it—when there will not be a wooden tie in this country and people will wonder we were such fools as to use wooden railroad ties; and so it will be with everything else. In our large cities we have fire districts where the use of wood for building purposes is prohibited and brick and stone and steel are taking the place of wood; so the disappearance of timber is not to be so much deplored as we think.

Then there is another question to be considered. This earth wasn't made for the purpose of growing trees, it was made for the home of man. Man is the crowning glory of creation, and all of the resources of earth, whether timber, or iron, or coal, or anything else, must be used for his comfort, and when one particular resource ceases to answer that purpose, it must disappear and be replaced by something better. Now 200 years ago this State of Michigan, almost every foot of it, was covered with a dense forest, a magnificent forest, and through it perhaps roamed a few wild Indians. Today these forests have disappeared and in their place are more than two million human beings living cilivilzed lives. The forest must be removed before civilization can begin to put in its work. Now which is better for the State of Michigan and for all the world, that we should have this country stripped of the forests and over two million human beings having a comfortable subsistence, or to have it restored to its original condition of a dense forest with a few wild Indians roaming over it? Suppose I should ask Mr. Todd whether he would think it was any better for him or for the State of Michigan if his peppermint fields were swept away and the original alder that grew in that swamp was put in their place. I don't believe any of us would consider it an

improvement. Just think of the millions of peppermint drops that our children would be crying for and in vain.

Now, I am getting to be an old man, and do not expect to live to see the day, but I look forward to the day when every available foot of land in the State of Michigan will be stripped of its original forest and be raising food for human beings. It is worth vastly more when it is raising wheat and corn than when it is raising pine trees; and leaving out these lands that won't raise wheat or corn or potatoes, I want to see every foot of that land stripped of its original forest and raising something that mankind can eat. If it has got to be planted by trees, let it be fruit trees or nut-bearing trees that can bring in an annual income instead of having to wait thirty or forty or fifty years to get a return. Now, there is one thing that our farmers might do to great advantage, and that is to cease to strip the timber off of these steep slopes. Where the mountain timber is removed the rains begin to wash away the soil. There they better leave the timber or else replace it by nut bearing or fruit trees.

But, I say, the disappearance of the forests is not to be regretted entirely. Why should we mourn for the old fashioned tallow dip with which our mothers used to light the house (and which I have helped my mother to make many times), when we have got kerosene and gas and electricity to replace it? Why should we mourn for the old fashioned wood plow when the steel one will do the work ten times better. For my part I do not greatly regret the disappearance of the forests because there is something better taking their places.

MR. STRONG: I think, as has been said, there are two sides to that question. It has always seemed to me that the belts of timber stretching across the country have an influence in shaping our winds. The velocity is checked by these belts of timber. Just the same when the snow is going over a fence; the velocity is checked and the snow drops there. Now if these belts of timber could be left—not all over, but in large bodies it seems to me it would be a good thing. But when it comes to changes of climate we must remember that this earth, as thousands of years go by, changes.

MR. SEARS: I would like to ask Col. Muenscher what he would do with these sand plains. How are you going to people them? If Michigan was a treeless state I should want to emigrate tomorrow. I am like Blackhawk—"I want the woods." In 1878 I was along the line of the F. & P. M. and there was a number of squatters located on those sand plains; they didn't want to cut down the timber on rich lands or go to the prairie, they squatted. I was up in that neighborhood making some repairs—it was a Sunday, and while the boys were making the repairs I went out into the field to look at the crops, and in passing along I dug up two or three hills of potatoes and put every one of them in my vest pocket. I then came across a sickly-looking pumpkin and put the whole of it in a cigar box. I do not know of any purpose to which these sandy lands can be put but that of growing timber. I met one time Mr. Renwick, a very intelligent lumberman of our region, and I asked him why he didn't clean up the waste and spoke to him about the valuable timber left on the ground that had blown down and scattered. He thought he couldn't afford that, but he did finally practice it, and he told me recently that he had lost thousands of dollars by not using a little care. If we had compelled these lumbermen a few years ago to have cleaned up their waste we would have ten times as much valuable timber in Michigan today. It has been a wicked waste.

COL. MUENSCHER: In reply to Mr. Sears' question I will say that I have been told or read somewhere that a very large proportion of the immense plain that surrounds the city of Berlin was once as barren as our pine plains and apparently as worthless. Now it is one of the richest sections of Europe and most densely populated. It may be like these German gardeners—that these men simply use the soil as a place to hold manure, but they do make something out of it. Now as long as we have better lands these pine lands will never be utilized; but the time is coming when they can be utilized. The great difficulty is the want of water. The population of this country is growing at such a rate that we have got to have some place to put them, and every available foot of land in this country has got

some day to be used as the abode of man. It may be that this soil has very little fertility in it of itself. Land that will grow the white pine trees that have been taken off of these lands, certainly has some elements of fertility that can be used in one way or other. I saw at the World's Fair an exhibit of potatoes that were raised in the state of Idaho, and there was a statement accompanying it to the effect that 972 bushels had been raised to the acre. That was simply the result of irrigation, and irrigation is something that we have got to come to in this state; our rainfalls are too uncertain. Some years we have an abundance, and some years when we do have an abundance it comes at the wrong time, and we may have a drouth just at the time when rain is most needed for bringing on our crops. But the time is coming when the farmers of Michigan like those of our western states will have to resort to irrigation. When they do I believe these pine plains will yet be utilized if they can only get water that can be placed upon it. I have seen on some of these old prairies the whole soil covered with blackberry bushes, and the finest berries that I ever saw, as large as my thumb, and as fine as any Lawtons that ever grew. What is to prevent that soil being used in the same way? An acre of blackberries is worth more than five of wheat. But a great deal of this land must not be broken up by the plow; the moment you break it up, you expose it to the sun and evaporation takes place to such a degree that the land becomes useless. Just leave it unbroken, put it in berries, fruit or nut bearing trees. But neither you or I will have to bother ourselves about this; there is plenty of land yet in Michigan that is good.

MR. SEARS: I should have said that of those squatters who went in there 25 years ago, probably not one in 25 are there today.

COL. MUENSCHER: The men who want to use that soil have got to go in there with capital.

MR. TEED: He has got the profoundest imagination a man ever had. Now if he can imagine a happy family surrounded with healthy and growing children living on these barren pine plains, he has got a powerful imagination. Now these pine

trees grow live on air almost entirely; but you cannot grow children on air alone. You go up there and look at those settlers and you will see a man, or what there is left of him, chopping on an old pine stump to get a little wood to cook his dinner; and you will see the children without any shoes, and running around perhaps in the snow; and the woman of the house, all shrivelled up, trying to get a little dinner. That is the happiness you will find up there.

MR. APPLETON: Could you tell us what the dinner consisted of?

MR. TEED: They didn't have any.

THE RELATION OF SEWERAGE AND WATER SUPPLY TO PUBLIC HEALTH.

The subject assigned to this committee is one that has already received abundant discussion in other associations and has been far from neglected in our own. In view of the many eminent sanitarians whose attention and study has been devoted to this question it is not to be expected that such investigations as the committee has been able to carry on, could lead to any important results of a general nature. It remains probable, however, that while to those familiar with the literature of this subject little can now be added, it may be possible to present to the lay minds a few of the fundamental principles and some examples bearing upon them that will be not only of interest but of value in developing a better knowledge among our members, of the importance of these matters.

Any consideration of the conditions affecting public health, must presuppose a knowledge of the causation of disease, and in order that this discussion may be clearly understood it is necessary that we review briefly the present theories relating to it. It may be proper to state, however, that the medical profession is yet far from a unit in the endorsement of these theories, and some of the statements here made may be violently combatted by many eminent and influential practitioners, particularly among those of more advanced years, but it is our belief that the doctrines here set forth are those most widely accepted, and they certainly have the endorsement of some of the most eminent investigators of the present century.

It is not necessary to consider those classes of disease due to abnormal developments, to wounds, and to inorganic poisons, but for present purposes we may confine ourselves wholly to those due to parasitism, *i. e.*, to those whose origin or development depends upon a germ. This germ may be of either the animal or the vegetable kingdom, and though its effects may be only produced by its death and decomposition, it must be at

some stage of the process possessed of life. While at one time it was maintained that these germs were self-productive, or capable of originating themselves, that view was dispelled by the researches of Pasteur and we may therefore conclude that every living germ of today has come from some other living germ of some day previous.

Leaving out for the present discussion a host of more or less common diseases that are supposed or proven to be affected by conditions that may exist in connection with water supply and sewerage our attention will be confined to the two most important that are supposed to be influenced by such relations. These two are diphtheria and typhoid fever. Like very many other diseases of the class under consideration their causes have been in the past, very generally misunderstood, and even today their discussion is not free from controversy. Both have been declared contagious and non-contagious; both have been apparently proven to be due to sewer emanations, and with both it has as clearly been proven that this cannot be the cause. Of the twenty-eight principal causes of death in Michigan for the ten years, 1881 to 1890 inclusive, diphtherial ranked second and typhoid fever ninth in mortality. [Rep. Mich. State Board of Health, 1894, p. cxxxix.]

Many extensive investigations have been carried on and a considerable amount of experimenting has been gone through with, to determine what relations sewers may bear to these two diseases, and what influence decomposing organic matter may exert upon them. The most careful observers have reached the conclusion that neither is *caused* by sewer gas or any emanations from sewers into the atmosphere. It is generally believed that both are germ diseases; that without the germ there can be no disease. It is further generally believed by those who are engaged in experiments upon these germs, that they cannot rise from damp or moist surfaces, and that their being taken up from sewage by air passing over it is impossible, unless they are thrown into the air by splashing. [Transactions Congress of American Physicians and Surgeons, Vol. III.] It has been found that there are actually fewer germs in the air of sewers than in that of ordinary school rooms. It

has been observed that those whose occupation leads them frequently into sewers, as plumbers and sewer cleaners, show no greater mortality from these diseases than do other classes of artisans. It has been found that these diseases occur as frequently in the houses of the wealthy as in those of the poor. It is well known that the most severe ravages of diphtheria occur in rural districts where sewers and sewer gases are unknown. It has been shown by the study of a large number of cases of diphtheria in Massachusetts that sewers could not possibly be the cause of the disease. A more recent investigation in the city of New York demonstrated the same thing and a study of diphtheria statistics in Detroit for 1890 shows the disease to have been most prevalent where there were no sewers.

It is now generally accepted that the typhoid germs must pass into the system through the alimentary canal, or in other words, that they must be eaten or drunk, at least swallowed, not merely inhaled, to produce any detrimental effect, and their place of growth and operation is in the intestines. On the other hand, the point of attack of the diphtheria germ is the throat and this germ may be and frequently is inhaled. It has been found that if the throat is in healthy condition and nothing occurs to produce an irritation of its membranes the germs may lodge in it and do no harm. The diphtheria bacillus has been found in the throats of perfectly healthy persons. [N. Y. Med. Record, April 14, 1894.] The experiment has been tried of keeping animals in an atmosphere of emanations from cess pools, and it was found that some animals not normally open to infection from the typhoid germ, became so during such exposure, and that they were most susceptible to its influence during the first two weeks, after which the animals seemed to become inured in their surroundings and were less and less liable to infection as time went on. [Chemical, Physical and Bacteriological Studies, A. C. Abbott, Trans. Cong. Am. Phys. and Sur., Vol. III.] From this it appears that though sewer gas and sewer odors cannot be considered the primary cause of diphtheria they may produce that irritation of the membranes necessary to the lodgment of the germs, and so

may be contributary factors in the production of the disease in certain cases, and they may so lower the general tone of the system as to render it a more easy prey to the specific germ of any disease.

As has been already stated the typhoid germ must be swallowed to produce an effect, unless of course it were to be injected into the system, and consequently we are to look generally for the causes of a case of typhoid in something eaten or drunk. Cooking or boiling kills the germ in a very few minutes, so cooked foods and hot drinks are generally excluded as possible sources of contagion, and we must look among foods eaten raw or slightly cooked and in milk and water for the germs in an active state. The well of surface water is a most frequent source of typhoid, whether the germs accumulate by surface drainage from cess pools, slop drains, privy vaults, barnyards and rubbish heaps, and the introduction of a public water supply is ordinarily followed by a marked diminution in the typhoid death rate. The state of Massachusetts, by an extensive collection of statistics covering many years shows this most conclusively. Mr. Hiram F. Mills, C. E., in discussing this subject, says: [Rep. Mass. State Board of Health, 1890, p. 527.] "The highest death rates by typhoid fever in the state are not in the cities (which all have public water supplies), but are in the towns that depend for water upon wells. The five towns highest on the list for the past eighteen years have an average death rate of 12.82 per year for each 10,000 inhabitants, while the five cities having the highest death rate by typhoid fever in the past twelve years. average 7.65 per 10,000 inhabitants and the average of all cities of the state in the same time has been 4.62. The town having the highest death rate from typhoid fever was Ware. In the fifteen years previous to 1886 the average number of deaths from this disease in 10,000 inhabitants was 16.5. In 1886 this town introduced a public supply of water and in the years since, although the water has not yet come to be generally used, the number of deaths has fallen to 6.9, or four-tenths as many as previously."

Such improvement is not limited to towns with high typhoid

death rates. Newberryport used well water till 1881. The nine years previous to 1881 showed a death rate of 4.55, but seven years after the water had been supplied from springs, the rate was reduced to 2.07. Many more cases of contaminated wells might be added, but one striking one will suffice. It shows that polluted water used to wash milk cans or bottles, will spread typhoid with wonderful rapidity among the milk consumers. This epidemic occurred in the spring of 1894 at Mont Clair, N. J., which is a resident suburb of New York and has a population of about 12,000. The town had previously been very healthy. The year ending June 30, 1893, showed but three typhoid deaths. In sixteen days, from April 2 to April 17 inclusive, 1894, fifty-two cases of typhoid were reported, of which six were fatal. An investigation showed that all were in houses supplied by one milk man, or else among persons who had recently partaken of milk sold from this dairy. It appears to be certain that the epidemic was caused by washing milk cans and bottles with water from a well infected by soakage from a privy vault known to have been used by two persons who but recently had typhoid fever.

Sewage contaminated waters other than wells have been most fruitful sources of typhoid epidemics. An interesting case occurred at Middletown, Conn., where the students of Wesleyan University were attacked by typhoid fever from eating oysters that had previously been infected by placing them in a stream of fresh water about 300 feet below where a private sewer was discharging the dejecta of two typhoid fever patients. [Rep. State Board of Health of Connecticut, 1894, p. 232.]

Perhaps no city has furnished a better example of what a sewage laden water supply will do than has Chicago in the past five years. As you all well know, the Drainage Canal is expected, when in operation, to reverse the natural flow of the Chicago river and turn the sewage inland toward the Mississippi river, and the authorities finally expect to purify the lake by intercepting all the sewers now flowing direct to Lake Michigan and thus divert their flow into the Chicago river or the new canal. For some years the city has been trying

to purify the Chicago river by pumping water from the south branch into the Illinois and Michigan canal and thus form a reverse current which draws fresh water from the lake. The capacity of these pumps is about 50,000 cubic feet per minute, and this produces in the lower end of the river a current of about one-third of a mile per hour under normal conditions. However, freshets, low water in the lake, or strong westerly winds, more or less overcome the works of the pumps and send the current of the river again towards the lake bearing with it sewage which speedily pollutes the lake in the vicinity of the intakes, as the epidemics of typhoid which invariably follow, clearly show. Further, it is estimated that the sewage from 400,000 people empties directly into the lake at all times. The average typhoid death rate per 10,000 in the twenty-one years ending 1891, for three large American cities, is as follows:

Chicago, 6.90; Philadelphia, 6.20, and New York, 3.19. While the death rate from all causes in the same period stands, Chicago, 208; Philadelphia, 212, and New York, 270, showing Chicago to be the healthiest of the three cities. Notwithstanding, we find that the typhoid death rate of Chicago in 1872 reached 14.26; 1881, 10.52, and in 1891, 16.64, while its minimum death rate during that period was 3.24. As a contrast during the year 1891, London's typhoid death rate was 1.40, Philadelphia's 2.14 and New York's 2.26—against 16.64 above stated.

That this excessive typhoid death rate in Chicago was caused by a sewage polluted water supply is evident not alone from analysis of the water in question, but as soon as the new four mile intake was in operation typhoid largely disappeared from the sections supplied from this tunnel. Thus the per centage of typhoid deaths to total deaths for the year ending September 30, 1892, was 6.72, while the year ending September, 1893, showed only 2.64, which rate is still higher than the rate of London or Berlin, both of which use a polluted water supply but not till filtered. It was also higher than that of Boston, New York or Philadelphia for the same year.

Again in the latter part of 1895 we learn that typhoid is

becoming epidemic in Chicago, but the health department says that the disease is still confined to the sections supplied from the one and two mile intakes and has not yet reached the section supplied from the four mile tunnel. The disease is thought to be partly due to recent dumping of filth dredged from Chicago river, and partly to the regular sewage discharged into the lake. In the meantime citizens are warned to boil all water before using it.

As late as September, 1896, we read in Engineering News that Chicago water supply is claimed to have caused the death of 3,000 infants and young children in the past twelve months. Besides these infantile deaths typhoid was said to be increasing and in twenty-one days in September there were sixty-four deaths. October 1, 1896, we learn that within the last fortnight the chemical analysis of the water from the various supply tunnels, have shown the water to be unfit for use and that there is a rapid and dangerous increase of typhoid, in fact so great, that the health officer seriously contemplated closing all schools supplied only with lake water. Further, a committee of the grand jury of Cook county has presented a report to that body which condemns the city water supply as unfit for use. There seems to be no present relief but to extend all of the water supply tunnels to four miles from shore.

Similar lessons might be drawn from Buffalo, Toronto, Windsor, Duluth and other cities, all of which have had more or less serious typhoid epidemics when they have been compelled temporarily to use sewage infected water.

From these examples of causes of typhoid fever it is readily seen that whatever may have been the immediate vehicle of the contagium, in the beginning water was responsible for its presence. It is unprofitable for us to enquire where the first germ of typhoid originated, but we may enquire how the germs come in the water, and it will be found that some time or other they were in the human body and passed thence into the sewer or soil and ultimately into the water. The importance of the proper disposal of sewage and household refuse

and the protection of the water sources of the State can now be appreciated.

In the rural districts and in small settlements of a few families the disposal of human waste ought not to be a serious problem, as the water supply can readily be kept at a safe distance, and the major part of the refuse from houses can be disposed of by animal scavengers, either four legged or feathered. There the dry earth closet or some other form of primitive disposal would meet the requirements, but unfortunately proper attention is seldom paid to sanitation in the country. When population increases and the hamlet becomes a village and swine are banished, the back yard becomes the dumping ground for all sorts of filth and then you have a problem which calls for the attention of the sanitary engineer.

Those who do not see any dangers in privy vaults and shallow wells or those who on general principles oppose all large public expenditures, are sometimes brought suddenly to realize the true necessities of the case by epidemics, as in Memphis, Tenn., but more frequently many human lives are sacrificed during long periods to lack of proper sewerage before any action is taken.

Cholera as well as typhoid fever is conveyed through water, —and in fact filthy ground and a contaminated water supply will account for very many diseases. Only disease can be expected when back yards are reeking with decayed vegetable and animal refuse, and wells are located in such grounds or close to privy vaults; under such conditions even the ever present fly brings death on his wings, for he carries with him the germs taken up from the manure and refuse heaps and distributes them wherever he goes.

The city cess pool is an abomination and a health menacer and should be abolished. Piles of slop and garbage in the back yards of the poorer classes of dwellings are to be disposed of. Our water supplies must be kept pure. These are among our duties as engineers. The question is, how are they to be provided for. In answer we would say: "Let every man in this society put his shoulder to the wheel and work for a law for the protection of Michigan water supplies. Give to

the State Board of Health power of approving and rejecting plans of sewerage, sewage disposal and water supply. Perhaps even go farther and give them power to compel present works to stop polluting lakes and streams."

In every instance where the State permits a city or a private company to erect water works, taking their supply from a lake or stream, it creates a monopoly for a corporation, and it is the duty of the State to compel that corporation to supply a pure and wholesome water. But, it is farther the duty of the State to guard the stream, lake or source of supply and keep out of it all sewage, manufacturing waste or other refuse which will in any way endanger the health of the people using from it.

The State Board of Health is selected as the custodian of the purity of the water supplies for various reasons. The relations already explained between water supplies and public health render it eminently fitting that this board should be so entrusted. The practice of other states which is set forth at some length in a paper by Mr. J. A. Harman in the report of the Illinois Society of Engineers and Surveyors for 1895, has been that here suggested and their experience has not as yet led to the suggestion of any change.

The necessity of state supervision is apparent when we consider that many municipalities are not able to command the services of competent engineers, or if able, are not sufficiently informed as to the requirements of their conditions or the abilities of the various members of the profession to make a judicious selection, and hence frequently fall a prey to those so-called engineers who are in reality only sales agents, and who always have an axe to grind; or else engage the services of some well intentioned but inexperienced man, who usually fails to grasp the problem in its entirety and the town, when through, finds itself with an ill-designed and perhaps almost useless system of expensive works. A State Board of Health employing a competent engineer, to whom the state could well afford to pay sufficient salary to retain the best, would be able in such cases to correct the errors of design, and thus

minister not only to the health of other communities but to the wealth of the particular one in question.

To the engineering profession this offers not inconsiderable advantage. The State Board of Health advised by a competent sanitary engineer, passing upon, commending, amending or rejecting plans, would soon bring about a marked improvement in the work of the profession, for those whose designs continually failed to meet approval would soon be forced either to improve their methods or go out of business, as no town would knowingly employ a man incompetent for his work.

From a financial point of view the people of the State must be gainers. Not only will individual localities be saved useless or unprofitable expenditures, but the State at large, through the improvements in health that must result from the systematic provision for the supply of pure water and the removal of wastes, will receive many times the additional cost of such a department. To those not familiar with the value of life saving work we would refer Reprint No. 472 of our own State Board of Health just issued, wherein it is estimated that during the five years from 1890 to 1894 inclusive, there were probably saved to the people of the State 112,800 cases of sickness and about 5,200 deaths from diphtheria, scarlet-fever, typhoid-fever and measles, which represents in money about $5,100,000, or over $1,000,000 annually.

This report is, gentlemen, very respectfully submitted.

G. S. WILLIAMS.
F. F. ROGERS.
H. E. RIGGS.

THE PRESIDENT: I have the pleasure of introducing to the society Dr. Baker of the State Board of Health and Dr. Wilbur of the department of Vital Statistics, and I wish to extend to these gentlemen, in behalf of the society, the freedom of the floor to engage in our discussions as freely as though they were members.

DR. BAKER: Gentlemen, I have to thank you for the very kind invitation; I came here, however, entirely to listen and not to make any remarks. I do not know that I have any-

thing to say beyond the statement of cordial thanks for the opportunity to listen to the discussions.

DR. WILBUR: I wish also to acknowledge the courtesy of the society. I have hastily put together a few figures on typhoid fever which I think will be quite in line of the general discussion.

The public health officer and the sanitary engineer meet upon especially intimate terms in dealing with the prevention of typhoid fever. A filth disease—not in the sense that it results *de novo* from filth, but that it is frequently associated with filth in its transmission by contaminated water supplies—physician and engineer alike must seek to reduce mortality from this disease by securing greater cleanliness. And cleanliness in this connection means necessarily not merely the absence of impurities apparent to the unaided senses, but a degree of purity that will sustain the most delicate chemical and bacteriological tests.

The common method of isolation practiced so usually in the restriction of dangerous communicable diseases has less than usual efficacy in dealing with typhoid fever. This disease is not propagated by direct personal infection as a rule, but usually is caused by the ingestion of typhoid bacilli derived from the fæcal discharges of an antecedent case, and washed, as a result of carelessness or ignorance, into the sewage and thence into the water supply. Strict disinfection of all discharges from typhoid fever patients, a sufficient quantity of an effective germicide being used for a sufficient time, will destroy all risk of infection, however faulty the construction of the sewerage system and however intimate its connection with the supply of potable water. But such disinfection cannot be depended upon at present, even in recognized cases of typhoid fever under medical care; much less will it remove the risk of contaminated water from the slight or ambulatory cases of the disease, in many of which no diagnosis is made. We must therefore depend upon the wisdom and enlightened judgment of the sanitary engineer for a large measure of the protection that we receive from incurring typhoid fever, and the general standard of opinion and practice in the profession

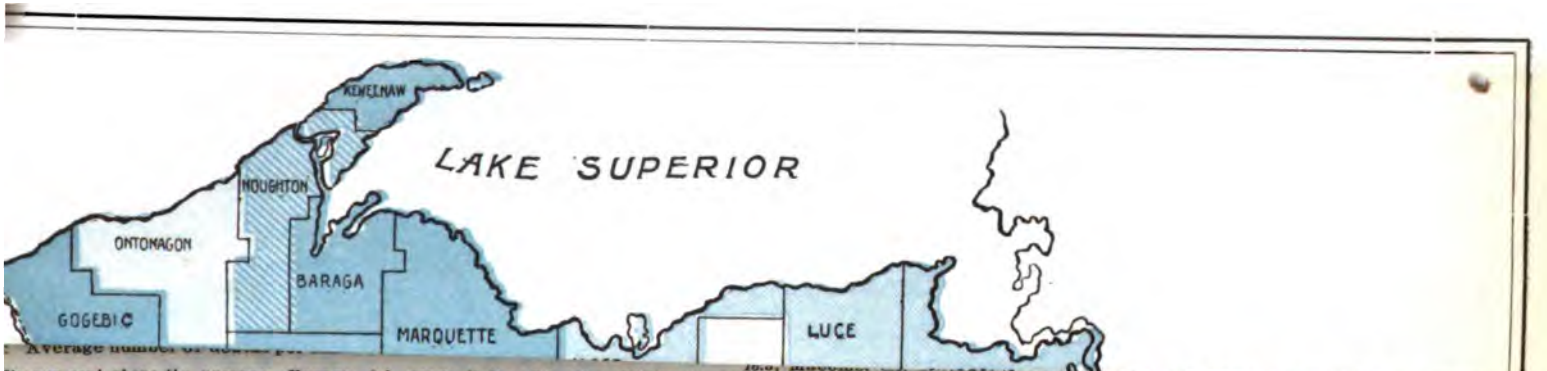
of engineering relative to sewer construction and water supply will be found to have a more direct relation to the suppression of mortality from this disease than the occasional spasmodic efforts of health officials.

For this reason, it occurred to me that this Society might be interested in a map and diagram showing the localities of greatest prevalence of typhoid fever in Michigan, as measured by the mortality returns, and how the disease has varied in importance as a cause of death in Michigan for the past twenty-five years as compared with other diseases. For convenience, let us make the comparison with scarlet fever, a disease readily restricted by ordinary methods of isolation, and which therefore presents a marked contrast to the course of typhoid fever.

We note that for the first few years of registration, a decline in the registered mortality of each disease took place to nearly the same extent. The death-rates were about the same. Since 1884, however, scarlet fever has shown a uniformly lower rate of mortality, and in recent years has caused only about one-half as many deaths as typhoid fever. With the exception of tuberculosis and diphtheria, typhoid fever is now the most fatal infectious disease with which we have to deal.

A partial explanation of the maintenance of the high death-rate from typhoid fever is given by the map, which illustrates the great mortality from this disease in the Upper Peninsula. In the mining counties, especially, and the cities largely populated by foreigners, an excessively high death-rate from typhoid fever sometimes prevails. But apart from this, too many counties of the lower peninsula show an excessive death-rate from typhoid fever. This is true of those containing the larger cities, and this in itself would seem to imply that the growth of population has outrun the increase of sanitary precautions. Since 1884 the yearly death-rate from typhoid fever in London has been less than that for England and Wales as a whole, thus conclusively showing that while increased density of population entails added danger from this disease, it may afford facilities for sanitary improvement in even greater ratio.

The following table exhibits the death-rates of Michigan



Average number of deaths per

fty per cent above the average: Baraga, 9.6, *316.2;* Delta, 8.4, *54.8;* Dickinson, quette, Menominee, (taken together since Dickinson was formed from the ers in 1891), 58.4, *75.3;* Gogebic, 14.8, *112.4;* Ingham, 20.2, *53.6;* Keweenaw, 6. 4, *19.8;* Montcalm, 6.2, *19.0;* Muskegon, 8.8, *22.0;* Newaygo, [illegible] Ottawa, 9.8, *27.7;* Sanilac, 7.0, *21.5;* St. Joseph, 6.6, *26.0;* Tuscola, 6.6, *20.3;* Van Buren, 8.6, *28.2.*

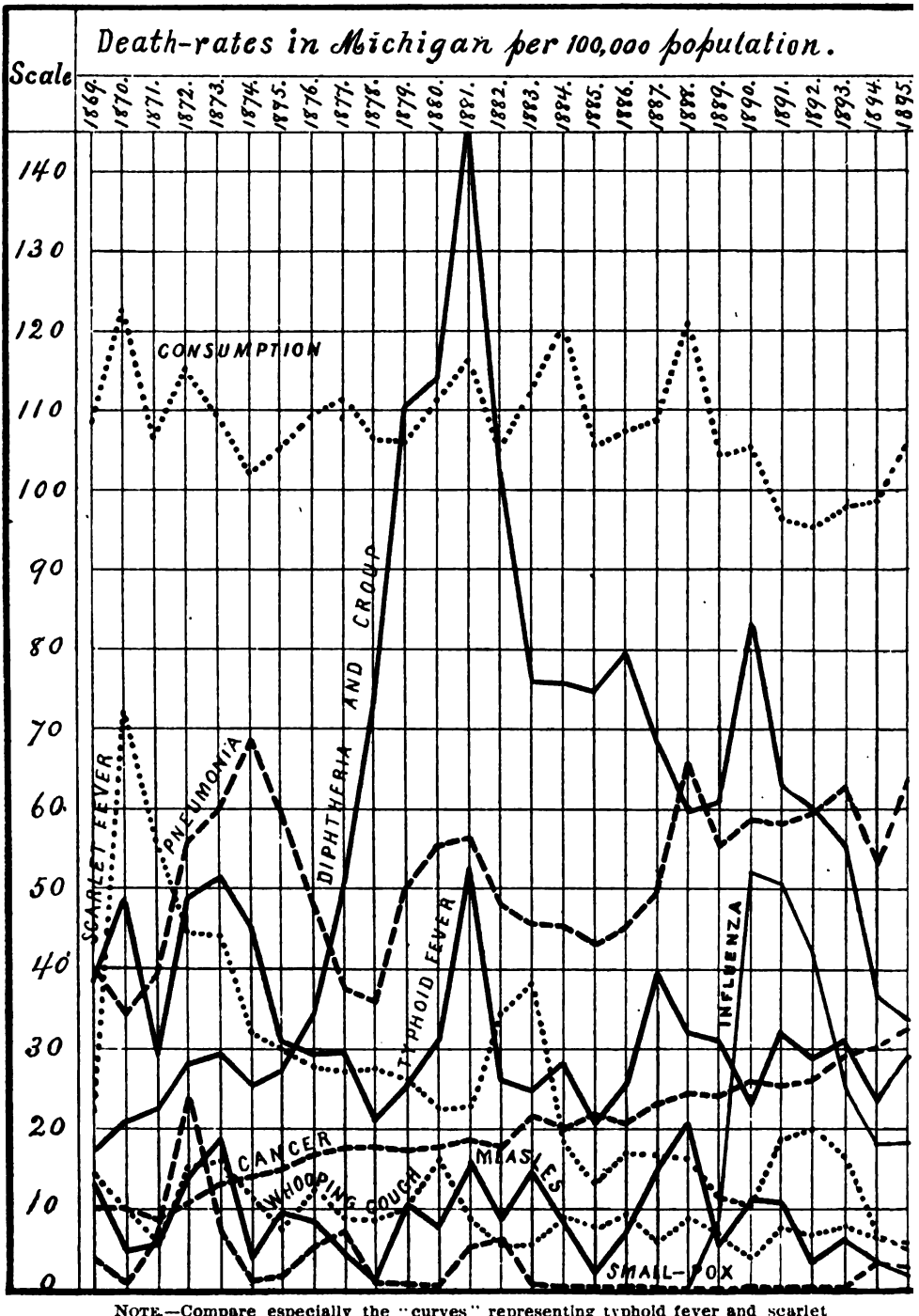
han fifty per cent above the average: Allegan, 11.8, *30.3;* Berrien, 17.0, *41.2;* 2, *25.5;* Houghton, 11.2, *31.6;* Kalkaska, 2.2, *42.6;* Kent, 45.2, *41.1;* Leelanau, 2.4, n, 4.8, *29.3;* Missaukee, 1.6, *31.7;* Oceana, 4.8, *30.6;* Saginaw, 31.0, *37.7;* Shiawassee, t. Clair, 17.8, *34.2;* Wayne, 84.0, *32.7;* Wexford, 3.4, *20.1.*

than fifty per cent below the average: Alger, 0.2, *16.9;* Antrim, 2.0, *19.2;* Barry, Bay, 16.4, *29.1;* Benzie, 0.8, *19.3;* Branch, 6.2, *33.1;* Calhoun, 9.4, *21.6;* Cass, 3.8, *18.1;* gan, 2.4, *20.0;* Chippewa, 2.8, *23.3;* Clare, 2.0, *26.5;* Eaton, 6.6, *20.6;* Emmet, 1.8, *20.6;* 6.2, *15.7;* Gratiot, 4.8, *16.7;* Hillsdale, 7.8, *23.4;* Huron, 5.8, *20.3;* Iosco, 2.4, *15.7;*

Over 50 per cent below the average: Alpena, 1.2, *7.7;* Arenac, 0.4, *7.0;* Charlevoix, 1.2, *12.4;* Crawford, 0.2, *6.8;* Gladwin, 0.4, *9.5;* Grand Traverse, 1.2, *9.0;* Ionia, 4.8, *14.6;* Lake, 0.6, *9.2;* Lapeer, 3.6, *12.3;* Livingston, 3.0, *14.4;* Mackinac, 0.2, *2.6;* Oakland, 6.0, *14.5;* Ogemaw, 0.8, *14.3;* Ontonagon, 0.2, *5.3;* Oscoda, 0.2, *10.5;* Otsego, 0.6, *14.0;* Presque Isle, 0.2, *4.8;* Schoolcraft, 0.6, *10.3;* Washtenaw, 3.6, *8.5.*

No deaths reported from typhoid fever for five years, 1888-92: Alcona, Manitou, Montmorency, Roscommon. The aggregate population of these four counties in 1894 was only 10,420 persons.

COMPARATIVE MORTALITY FROM CERTAIN IMPORTANT DISEASES IN MICHIGAN FOR TWENTY-SEVEN YEARS, 1869-95.



NOTE.—Compare especially the "curves" representing typhoid fever and scarlet fever. See data in table on next page.

and England from scarlet fever and typhoid fever for four consecutive quinquennial periods. The rates of decrease in the death-rates from scarlet fever are much the same, but the stationary mortality of Michigan from typhoid fever stands in marked contrast to the progressive decline in the English death-rate from this cause:

DEATH-RATES PER 100,000 POPULATION FROM SCARLET FEVER AND TYPHOID FEVER, IN MICHIGAN, ACCORDING TO THE RETURNS,* FOR THE FIVE-YEAR PERIODS, 1871-75, 1876-80, 1881-85, 1886-90 COMPARED WITH THE CORRESPONDING RATES FOR ENGLAND.

Causes of Death.	State or Country.	Deaths per 100,000 Population.			
		Five years, 1871-75	Five years, 1876-80.	Five years, 1881-85.	Five years, 1886-90.
Scarlet fever	Michigan	41.0	26.1	25.1	14.2
	England	75.9	68.0	43.6	24.1
Typhoid fever	Michigan	41.1	27.7	30.5	30.1
	England	37.4	27.7	21.6	17.9

What are some of the practical deductions to be drawn from these statistics? It seems to me that they show that sufficient attention has not been devoted to the supervision of sewerage systems in many localities in this State by their local boards of health. Possibly also, but on this point the members of the Society are better qualified to form judgment, sufficient attention has not been paid to the sanitary requirements of sewer construction in the education of the engineer. Our health officers are often appointed for political reasons and hold their positions for a limited time. Under such conditions, the tendency is to devote their time especially to those fields of preventive medicine that yield the most immediate results. A considerable amount of technical education is absolutely necessary for the health officer before he is prepared to coöperate intelligently with the constructing engineer, but cannot be demanded at present with the low compensation and uncertain tenure of office usually given him. In time, no doubt, we shall have this unsatisfactory state of affairs changed for

* The returns for Michigan, under the present system of registration, are very imperfect. They should be increased probably by about 60 per cent to be comparable with those of England.

the better, and we can then reasonably expect that the death rate from typhoid fever will begin to decline in the same way that it has done in England.

THE PRESIDENT: There is one point in connection with typhoid fever that I would like to bring up. Some three years ago a younger brother of mine had charge of the street improvements which were made in a small interior town in northern Ohio which had been settled for about a hundred years. They have had and I believe now have no sewerage other than surface in that town. After the work had been completed there was an epidemic of typhoid fever along the streets which had been disturbed. I have known of some other instances where old towns, in digging up their streets for sewers and other improvements, had a like experience in epidemics of typhoid fever following upon such improvements. I would like to inquire what is a fair explanation of this typhoid fever occurring after these improvements in these old towns.

MR. ROGERS: I don't wish to take the time, but just in line with your remarks I wish to state a point that Mr. Williams did not cover in regard to our town. During the year of the continued dredging of Black river, we had a serious epidemic of typhoid fever, and the refuse from the river was all deposited a mile or a mile and a half below the intake pipe of our water works, and it could not be possibly accounted for by contamination of the water supply. Samples of our water were sent to Ann Arbor for analysis and pronounced pure. In finally occurred to me, and I think Mr. Williams agrees with me, that the only possible chance for that occurrence would be from the dry material on the dump scows and the dry dust that blew, perhaps, on to delivery wagons, or milk wagons, or other conveyances, passing across the bridges and along the docks, and thus got into the mouths of the people.

MR. WILLIAMS: New York ranks as low as any of the American cities in mortality, and while the conditions in New York are in many respects such as would lead one to anticipate high mortality, that is if unsanitary surroundings had anything to do with it, from the crowding of a large population

into close, narrow quarters, the immense population in a district, the many families living in a block—all these things which one would expect would have a marked effect, seem to fail to produce it, and this is largely to be explained, as many think, in the fact that the New York water supply, after it is gathered from the surrounding country, is stored for months before delivery, so that any germs that come into it are liable to die a natural death before it passes to the city.

There has been much said in the reports of the State Board of Health on the relation of low ground water to typhoid fever, and I have read a portion of that investigation with a great deal of care and interest, and it seems to me that while it is perfectly proper to apply it to the State as a whole, since the supply of water is largely drawn from wells outside of Detroit, and under such circumstances the relation is properly applied, yet I think the results of the investigation can hardly be applied to Detroit because our water supply comes under different conditions. In regard to this general low ground water, it hardly appears to me likely that it in itself could affect typhoid fever in Detroit, as 99 per cent of the residents of Detroit use or receive water from the Detroit water works. The actual figures compiled last July show that less than one per cent receive water from any other source, and while low ground water undoubtedly affects the condition of the wells, I fail to see where it can affect the condition of the water in Lake St. Clair, and I think the effects upon the Detroit water supply are to be looked for elsewhere.

DR. BAKER: Mr. President, gentlemen—As I said when I was before you first, I came not prepared to make any remarks; I only learned of the meeting yesterday afternoon, and of what was to be presented. But I wish to express my pleasure at having been permitted to hear the papers that have been presented here, and if you will pardon the disconnected way in which I may present it, I would like to say a few words on what has been presented here. I want in a few words to emphasize the plea for greater attention to water supply and sewage because of its lessening of the rate of mortality from typhoid fever, and to call your attention here to

Munich, which in 1890 had eight per hundred thousand deaths or mortality from typhoid fever and to recall the fact that in 1854, when Munich disposed of its fecal matter in privy vaults and drank the water from wells, the mortality, instead of being at this rate, was 240. I do not recall the exact dates when sewage was put in in Munich, but I know that the mortality rate from typhoid fever there gradually decreased until in 1884 it was four per ten thousand, which would be forty per hundred thousand, and now it is even lower. It is claimed that the mortality in Munich at the present time from typhoid fever is only those that are brought in from outside, if they have any at all. The doctors in the hospitals count themselves fortunate when a case is brought in so that they can submit it to the students. It seems to me that is the most important illustration of the decrease of typhoid fever by the introduction of pure water and the proper disposal of bacteria.

I think we all of us recognize the fact that we need the exact figures with reference to the mortality. I would like to suggest that the reduction in scarlet fever to which Dr. Wilbur referred has resulted from the movement that has been going on in this State of educating the people themselves. The mortality from scarlet fever did not lessen in Michigan until the State Board of Health adopted the principle of sending to every locality where the disease was the instructions with regard to reporting to the health officer every case. The State Board of Health was established in 1873, and very soon afterwards commenced the system of proper instructions. The law required that scarlet fever should be reported to the health officer, and the law also requires that the health officer shall report the same to the State Board of Health. Now the purpose of reporting that to the State Board of Health is this: That the board may supply that locality with leaflets which tell definitely how to restrict that disease; and on every occasion when that disease has been reported to the State Board of Health the leaflets have been sent to that locality and the health officer has been asked to distribute them. Now we believe that the lessening of mortality from

scarlet fever is in no small degree due to the work done in this way. In 1873 the mortality rate was 4.85, but since that method of educating the people themselves has been adopted, it has been less than half that; up to the year 1890 it was 2.24 instead of 4.85, and counting it up to 1895 it is 2.07. Now that mortality has been reduced by the people themselves in keeping the neighbors out of the house. For only a short time that has been going on, but a reduction has occurred, and we believe there is a relation of cause and effect there. That method, if continued, will reduce the mortality rate from typhoid fever. Those diseases which cause the most deaths in Michigan are represented on that diagram; today there is no small-pox in the State, and that is one of the diseases of the most importance. Typhoid fever claims a death rate of about one thousand persons a year in Michigan. We believe there are about ten thousand cases a year, as the rate is about ten cases to one death. Now as to the proposition of the committee: If that has the result that we all hope for, the doing away with one thousand deaths in ten thousand cases a year or not, there may be a difference of opinion. I believe it will. I didn't know that it was thought of presenting this subject in this State until yesterday, when I heard that you were going to discuss this subject today; but it seems to me it may help us to do away with that thousand deaths in ten thousand cases of sickness, and if that is true the movement ought to be well talked up beforehand, because several things must be done. The appointments to the State Board of Health, it seems to me, ought to be differently considered, if the State Board of Health is to take up this work, which has been done in Massachusetts, and Ohio somewhat. I know that in Massachusetts the State Board of Health is required to examine and approve or disapprove the plan. If this is done, I think the members of the State Board of Health must be selected with reference to this work; now they are selected with reference to other work, and the Governor and the Senate must take this thing into consideration. I do not know how your law would be framed. I notice the committee suggested a consulting engineer, and I suppose he would be constantly em-

ployed by the State. I presume that something of this kind could be done, but it ought not to be done too speedily, because, as I said before, several things must be done to harmonize with that. The members of the State Board of Health must be selected with reference to it, and time must be given to get it properly planned.

Speaking now for the State Board of Health on that special point: Of course we all desire the continuance of the State Board of Health, and this point is worthy of consideration, whether or not it can endanger the existence of the State Board of Health. Every session of the legislature this board is attacked by those whose business has been interfered with. There are quite a number of large corporations, some of which keep a man employed at the capital all of the time. The State Board of Health understands plainly that if it should be called upon to approve or disapprove the plans of cities and villages around the State, and when the board disapproved of the plans of some of the villages and cities there would be a certain number who would disapprove of the disapproval by the board and thus the board be attacked. That is a point I just throw out for you to consider.

I have taken more time than I expected, and I wish to thank you for the opportunity of having heard the papers.

MR. RIGGS: Relative to the work of the State Board of Health in other states, the state of Massachusetts comes pretty near leading the world in its work of investigating the subjects of the purification of sewage and water supply. They do not pay nearly as much attention to vital statistics as the Michigan Board of Health; their work is largely in relation to sewerage and purification of water. They have money, plenty of it as compared with what we have in Michigan or in Ohio. New York has a law giving the State Board of Health authority to approve plans of sewerage and water supply. Their reports are valuable for other features; but they are particularly valuable to the engineer by reason of the fact that they publish those plans so that when you get the report of the State Board of Health you can see what is going on there and see what engineers are doing. Ohio is a good deal

like Michigan in that she has very little money to carry on the work of the State Board of Health, I think something like from four to six thousand dollars a year being all that is allowed. The Ohio Board of Health is selected very largely as the Michigan board is, that is without any particular reference to the work of sanitary engineering. The consulting engineer in Ohio is generally the head of the engineering department of the State University, a small per diem and mileage being paid in addition to the general salaries for the time spent in looking over the proposed plans, and once and a while they have called in an outside consulting engineer. Dr. Probst, the secretary, has thoroughly investigated nearly every point; and while I do not know that he has ever given any special attention prior to the time that this work was given to him, he has done a wonderful work. I want to say to the members of this society that the city of Toledo knows that Dr. Probst is alive. The new general law doesn't cover the old sewer districts, but it does reach into all the new sewer districts and all cities proposing new plans. We have established new sewer districts and it has taken just about four years to get plans that would be approved by the State Board of Health. Our city has wasted a large amount of money on its sewer system in the past, but from this time on, thanks to the Ohio law and to our efficient city engineer, it will adopt a new line of work, and sewers on the separate system will be put in in three districts in our city next year. I believe the powers of this State Board of Health might be extended. I would not carry them far enough to get the board into trouble, but would give it advisory powers in the beginning. I believe that the board as now constituted, calling upon the professors in the University and in the Agricultural College when it is necessary for them to have aid in passing upon engineering plans, would be abundantly able to undertake this extra work. I believe it is the duty of every member of this society to encourage the State Board of Health in the work they are doing.

MR. APPLETON: As to these reports, the issue of the publications of the reports for the last number of years I have no doubt has been of the greatest possible value to the State of

Michigan in lessening its death rate, as has been shown on that diagram they have published. But I do think to undertake to legislate such a sweeping measure as has been spoken of here, knowing something about the feeling that has been mentioned by Dr. Baker, would be to jeopardize the whole thing. Now I think that the State of Michigan would hardly be prepared for it, while I am satisfied that if it was constituted right with the right members of the board, that it would be a good thing perhaps as a whole, but I do think that it would be a little premature to undertake to give them the power over every work that was done in every city or small place in the State at this time. They are dong an excellent work and they are improving in that work; they are becoming better and better every year, and I think it would be rather unwise to force on them so much, and I do not think it would be quite wise to undertake to do so much as has been advocated here.

PROF. DAVIS: I would like to say a couple of words. A case was brought to my notice this winter of a Long Island town advertising for a resurvey and the map of the town—city, I think they called it—including the exterior boundaries, the location of the streets and landmarks preserving the location, the making of a set of street grades including the provision for a system of sewerage, inviting bids from all over the country, and for computation as to the price of how much per acre they would make this resurvey for and also the total price for the whole job. There was no evidence that anybody knew where the boundaries of the town were, there was no evidence that anybody knew where the streets were. Some of my young friends wanted to make a bid, and they consulted me as to what it was worth. I answered that leaving out the proposition for a complete system of sewerage for that town which the advertisement called for, and leaving out the proposition of ascertaining the original boundaries, since nobody knew where they were and how much work it involved, that I thought somewhere from eighteen to twenty dollars an acre ought to accomplish it. It went for $1.90 an acre including the sewerage. Now there are hundreds of towns and cities

of the smaller size in Michigan that do not need a system of sewerage, and the State Board of Health should have conferred upon it the obligation of seeing in the first place whether these towns need sewerage at all or not, and these towns should not have foisted upon them by a few designing men the expense of building a worthless sewerage system. That is a point which the committee does not cover. There is scarcely a small or large city or village of any size whatever that ought not to have forced upon it, if necessary, a practical sewerage system; and in all small cities, a practical system, by a proper organization—in my private opinion again—of house to house collection, can be made to do a large part of the work which the poor sewers in many of our towns at the present time do not do, besides doing that part of the work which no sewer system can ever do. I know of charters of cities in the State of Michigan today which present an interesting and curious state of things which perhaps might be profitably mentioned here. To be specific, the charter of the city of Ann Arbor says that the money of the taxpayers shall be voted away by the electors; the public money can be voted for public works by the electors —not by the taxpayers, but electors. You scratch around to find out what an elector is and you are referred back to the constitution of the State of Michigan, and you discover that in Michigan an elector is a character of this kind: I may not have the details of the picture perfectly correct, but in the main: He may be a gentleman with a little baggage landing in the State, and for some inexplainable reason detained there six months, where he then becomes a voter willy nilly I suppose, and if he happens to stay at the same place in the State and his boarding mistress does not discharge him for six weeks previous to any election, he has the right, privilege, obligation or whatever you please to call it, of voting in that locality. Now here is the condition: We will suppose that a certain company wants to build a system of public sewers in the city of Ann Arbor; they have nothing to do except to move a parcel of laborers on there from Grand Rapids or Detroit, or any other place within the State that they can get

them from, and settle them there and maintain them there for six or eight weeks, and then they are in a position to vote anything on to the city of Ann Arbor that they please and we cannot help ourselves; they can take a woman's property and she has not the liberty to even say "No."

MR. WILLIAMS: Regarding what Dr. Baker said as to the necessity of a change in the constitution of the State Board of Health, in the event of those powers being given to it, I would say that my judgment concurs with that of Mr. Appleton, that no move should be made prematurely. Yet this is a matter on which the people of the State must be educated, and the members of this society can do a great deal to educate them. It only needs a little talk by someone who has a personal knowledge of facts to create a vast amount of public sentiment. I should certainly be opposed to taking any measure at this time to bring about any action of the present legislature on the subject. It has been my observation in the city of Detroit that the best results seem to be obtained from those boards on which the members themselves participate the least actively in the operation of the work under their care. Those boards on which the members act as a sort of court of appeal or board of review I think are getting the best results. My idea would be that the State Board of Health need not be changed from what it now is, but should simply add to its force of assistants a competent engineering department. Now the board of water commissioners for the city of Detroit has a general superintendent who has control of the works, and he is responsible for its operations. The superintendents are responsible to him, and their reports are made to him, except an annual report of each, which is made direcly to the board. They of course have the privilege of appealing to the board if they see fit against the decisions that have been made by the general superintendent; but the general superintendent has the actual control of the operation of the works, and the commissioners do not interfere any more than to take his recommendations and deal with them, and either endorse or disapprove them. The individual commissioners very seldom come in and undertake an active participation in the oper-

ation of the works, and we are able to show to the people of the United States that the Detroit water works are carried on the most economically of those of any city in the United States of its size, which is a fact that was shown—not by our own testimony, but by the testimony of John W. Hill, of Cincinnati, who compiled a table, published in the report of the engineer commission on the improvement of the Cincinnati water works, showing the actual cost of maintaining and running water works in various cities to which you are referred.

In regard to the extent to which this board should have power, it certainly should have the right, not only to approve and disapprove, but to recommend, for the very reason that small cities cannot afford to engage competent help to design their system for them, and the State can afford to pay one competent engineer to do this work for all.

There is another thing to be borne in mind in connection with this agitation. I am a Michigan man, was born in Michigan and have lived here practically all my life. I am proud of Michigan, and yet I am not so proud but that I can see some faults in the nature of its people. Michigan was settled at a time when communication with the east and communication with the west, in fact communication with anywhere except Michigan, was very difficult. Its citizens were schooled by the necessities of the case in self-reliance, and as a result it is today, a peculiarity of Michigan men that every one of them thinks that he can do everything that comes to him just as well as anybody else on earth, and the reason is simply because our forefathers had to do it, and they did it as well as they knew how, and they thought they did it pretty well, and a good many of them did. Now that very thing is a thing that can't be overcome in a minute. You can't go to the average citizen of the State and tell him that he don't know as much about health and law and engineering and so on as anybody else. He thinks he knows as much what they ought to be as anyone does. Now that is a condition that must be taken into account in bringing about the results we advocate. This society should go on and take this matter up and begin a career

of education. Let us begin talking about it to our neighbors.

MR. RIGGS: I don't think it was the opinion of any member of the committee—it certainly was not mine—that any bill should be introduced at the present session of the legislature; but it was my belief that this report should be the opening gun; and I believe that every one of the members of this society feels a personal interest in it no matter what line of engineering he is engaged in—this society can do a good deal in helping the board of health.

MR. ROGERS: It would seem to me that while we may not be ready to ask the legislature to prepare anything, some sort of a resolution would be a good thing to open the campaign with and get people to talking about it.

MR. WILLIAMS: I submit that a committee be appointed to report such a resolution to the board of directors at their first meeting for their approval. I think we can trust them to approve a proper resolution, and a thing of that kind should have some care in its preparation and should be given a prominent place in our report, and I am not in favor of going into anything of that kind on the spur of the moment. I move that a committee be appointed to prepare a resolution to be submitted to the board of directors and to be printed in the annual report in such a conspicuous place as to attract the proper attention.

Motion supported and carried.

Messrs. G. S. Williams, J. B. Davis and Frank F. Rogers were appointed such committee, and later made the following report, which was adopted by the directors.

WHEREAS, Typhoid fever and other diseases are extensively distributed by impure water; and

WHEREAS, Public water supplies are often taken from sources liable to dangerous contamination; and

WHEREAS, The increasing density of population makes it ever more difficult to obtain such supplies free from possible disease infection; and

WHEREAS, Many municipalities do not select capable engineers to design, construct and organize their various works

for the preservation and improvement of public health; therefore, be it

Resolved, That it is the sense of the MICHIGAN ENGINEERING SOCIETY, that the preservation of the health of the people of this State requires every member to cultivate, encourage and extend, so far as may be in his power, a sentiment favoring State supervision of works for public health; and further be it

Resolved, That it is the judgment of this society that such supervision will be best administered by the State Board of Health.

G. S. WILLIAMS.
J. B. DAVIS.
F. F. ROGERS.

REPORT OF COMMITTEE ON ACTION OF FROST ON CEMENT MORTAR.

E. W. MUENSCHER.

COL. MUENSCHER: During the past year I have been watching the engineering periodicals very closely, but I confess I have not come across anything that I thought was outside of what was contained in the report of last year. The other day there was a new paper sent to me called "Self Help"—I presume it came from our friend LaRue, of the Scranton School of Correspondence—and there is a little in it that I thought would be interesting. I will read it, leaving out what is said about hot weather:

In freezing weather, the action of frost creates many difficulties; the moisture of the earth is formed into an ice cement by its action, and the earth becomes practically a mass of concrete for a depth of from 3 to 5 feet, according to the degree of temperature and the nature of the materials. When the material is loose and cellular, the frost does not penetrate so deeply, owing to the non-conducting property of the air in the cells or interstices; but where the material is well compacted, as under streets and roadways, it penetrates considerably deeper, and thus renders the work of excavation tedious and expensive.

Since ice is formed when the temperature touches 32° F., this is the danger signal for the builder. In summer, the temperature of the building materials could be kept to a normal condition, as before mentioned, by keeping them cool and moist; but in winter, it is essential that they be kept warm and dry. Under certain conditions this may be effected, but it is always attended with more or less risk. In the case of lime mortar, used during a continued period of freezing weather, where great care was taken to use rich, newly slaked lime, thoroughly well mixed, like putty, and retaining much of the heat of slaking, comparatively good results have been

obtained, when the brick or stone was kept under cover to keep them dry, and the thermometer has not varied much. The danger, however, lies in a sudden thaw taking place, or in a hot sun basking on one side of the wall and thawing the mortar, doing material damage to the wall by causing it to buckle out of plumb.

It has been found that there is greater danger in using stone than brick, owing to a peculiar property of ice called viscosity. Water, in freezing, gradually expands about one-ninth of its bulk; in other words, nine gallons increase to the bulk of ten gallons during the process of changing from water into ice, the temperature being 32° F. in both cases. This explains the enormous power exerted by water in freezing. Owing to the property of viscosity, however, it has the power of adjusting itself to circumstances. Viscosity may be explained as that glutinous and imperfectly fluid state, characteristic of molasses; while far from being limpid, it slowly changes its form, should the surroundings be prepared to accommodate this elastic tenant. To illustrate this property of viscosity, let a rigid iron vessel, with holes in the cover, be filled with water and the water gradually frozen, it will be seen that the expansive force exerted by the water in freezing, will gradually force the ice through the holes in the cover and stems of ice will protrude like so much macaroni.

Brick being open in texture, especially the common varieties, allow the expansive force to send out prickly ice-shoots from the body of the mortar. These ice-shoots, by entering the cells in the brick, allow a closer contact between the particles composing the mortar, and a more perfect set takes place than would otherwise result if the ice could not enter the interstices of the brick. With stone, however, the grain being closer, the result is different; since the ice-shoots cannot enter the stone, they form themselves into an ice film which alienates the intercourse of the particles. The expansion destroys the contact between the stone and the mortar, the effect being that when the thaw comes and the moisture is exuded no bond of adhesion exists; a cellular mortar remains, which appears like pumice stone and is of little value. At the surface, the

particles are disintegrated by the action of the frost; but the ice cement holds them in position until it is dissolved by thawing, when they fall off in powdered masses.

A strong argument in favor of the use of hydraulic cement-mortar in winter weather is, that the set takes place more rapidly, and if well begun, subsequent frost does not appreciably disintegrate or pulverize it; the particles in combining, expel the excess of moisture; a much closer contact is secured between them; the body is more dense, and the effect of the frost is not apparent after thawing. In order to reduce the freezing point, a solution containing 2 or 3 per cent of salt is mixed in the mortar, which reduces the temperature of freezing about 5°. In other words, until the thermometer registers, say, 28°, the operations are safe. This, however, is done at the sacrifice of much of the strength of the cement, it having been conclusively proven that any addition of salt to cement is injurious (in the same manner as the addition of sand reduces its value); the salt crystallizing, creates a force in opposition to adhesion, and disintegrates the particles; at the same time the salt possesses the property of attracting moisture, and as it does not evaporate, it remains in the mass.

Although the appearance of the work has not suffered by the action of frost on the cement, still, the result of many experiments has shown that the strength of the cement-mortar suffers very materially, losing as much as one-third of the value it would possess were it not frozen. It is imperative that the top of the walls be kept covered when the work is not being prosecuted, so that the rain and frost may not enter and separate the constituent parts of the masonry. Sheets of tarpaulin or roofing felt are most convenient for the purpose.

THE PRESIDENT: This International School of Correspondence publishes a paper which they call "Home Study." Is this a leaf from that?

COL. MUENSCHER: Yes, I think this is the same place it comes from; it is the first number, sent to me as a sample.

THE PRESIDENT: This paper, "Home Study," of which I have read a number of copies, is quite elementary in a great deal it has to say; but it presents it in a different manner than

I have seen it presented in text books or in a great many papers, and I believe it is a valuable paper for every engineer to have on his list of periodicals; it is low priced, $1.50 a year, and I think it is one of the most ably edited periodicals of the kind published.

COL. MUENSCHER: I would state that this is republished from the July number of "Home Study" periodicals.

MR. PARKS: I have something to offer which is perhaps in a way confirmatory of what was stated in this paper, simply a bit of experience which I had something like three years ago. At a place where I went to install an engine I found the foundation had been made up during the month of February with a mortar composed of a part cement and a part common lime, just in what proportion I don't know, I wasn't informed as to that; but the condition of the foundation was such that you could crumble the lime or the cement all up in your fingers. The foundation had been laid in an open room where it was not protected from the cold in the least, and so far as its value as a foundation was concerned was absolutely worthless. Right beside this foundation was another one which I was informed had been laid up at the same time, and it was composed of mortar or cement with common brick, or rather a hard burnt brick. This foundation I found to be in excellent condition, in fact it did not show any of the effects of disintegration such as is spoken of in this paper. I have never been able to explain to myself to my own satisfaction what was the cause of the different effects on these two foundations; but I believe this paper explains it, and it confirms also what was stated right here.

MR. HODGMAN: I would like to inquire about that bridge pier at Manistee that they had so much trouble about, if there is anything new.

COL. MUENSCHER: I dug into that a few weeks ago with a coldchisel, and it took me two straight hours to get through three or four inches of it.

MR. SEARS: What did you use for a driver?

COL. MUENSCHER: A hammer.

MR. ROGERS: I would like to ask for my own information how long it was before that began to set?

COL. MUENSCHER: I cannot tell you. It was a cylinder of steel filled with concrete, and all that we got at we cut a hole in the cylinder and dug in and found it all a crumbly mass like sand; but I dug into the same place recently and found it solid.

MR. ROGERS: I would like to ask how long it was from the time of building before he examined it.

COL. MUENSCHER: The next summer.

MR. ROGERS: Probably six months.

COL. MUENSCHER: Yes, sir. In a large cylinder like that the cement of course sets very slowly; it will probably be a good many years before it is thoroughly set in the interior. But in the last two years that bridge has not settled a hair, as I can discover. We put a surface on top with a masonry of Portland cement, smoothing it off perfectly smooth, and you cannot see a sign of a crack in it with all the weight of that draw span resting on it.

MR. SEARS: Do you think that when that outside is worn off the pier will stand there without any protection?

COL. MUENSCHER: I will be out of the way then.

MR. SEARS: Perhaps some of the younger men can inspect it in 25 or 30 years.

REPORT OF COMMITTEE ON MATERIALS FOR STREET PAVING.

WM. APPLETON.

Gentlemen, the few minutes I occupy your valuable time I shall speak only my own experience, and observation, leaving the numerous books and periodicals, to deal leisurely with the purely technical, and scientific phase of pavement in its various forms. The rapid transformation of this immense continent from a wilderness trodden only by the feet of savages into a fertile agricultural country, with smiling fields, luxuriant pastures abounding with flocks and herds furnishing abundance of all the necessaries of life, this region so well supplied with water courses early became dotted thickly with manufacturing villages at the rapids in the streams. These soon became cities where the luxuries of life were dispensed and exchanged for the food supplies furnished by the fruitful fields, thus grew together manufactures and commerce, whose first need was intercommunication and so railways, telegraph, rapid transit, everything else seemed to have outstripped and left behind the subject of our paper, for long after we had railroads from Dan to Beersheba we were stuck fast in the mud going a few blocks to church. But common sense rebelled against such a policy when we found a ton of freight cost more to drag two or three furlongs in the mire than it did two or three hundred miles on a tram-road, and it only needed a moment's thought and the thing was done. The path had been beaten for us for generations. The Romans had never been surpassed as roadmakers or pavers; could we not even at this late day take a lesson from them and make our roads narrower, and put the extra expense in excellence in the track? But we will stick to paving. Pavement may be broadly said to consist of wood blocks, cobblestone, brick, or as they are getting to be called blocks, and the famous Scotch pebble. Cedar blocks have been to our city what the corduroy was to the country, a big thing

at first, after being accustomed to none, and if well laid on a well-prepared bed, with good drainage, the blocks sound, we have a fair pavement for about ten years. Of the two generally accepted methods of laying blocks one is to make the bed on the sand, lay on the blocks as close together as possible, fill in the interstices with the pebbly shot-like filling, and the thing is done. I had almost forgot to set before the filling, make firm either by tamp, roller or both. The other way is to make the bed solid and form it as before, then place a layer of a low grade of inch boards, put on the blocks, on the boards fill in the chinks with fine gravel. The boards are generally laid diagonally across the street. Now for the advantages and disadvantages of boards. Unless the bed is very well prepared very evenly packed with the greatest care by compacting with rammers or very heavy rollers, or both, the blocks settle unevenly. The boards of course in a measure prevent this, and one set of boards outlasts two sets of blocks, but the first you know along comes a sewer, water pipe or something else and those boards which were laid carefully with the joints broken, and you have to cut through as wide as the trench. Just imagine the disturbance caused to the entire street, and it is spoiled for good job. Any ordinary block pavement is very short lived, about ten years, and much of that time the sap is rotten. It gets uneven, hard to clean, and readily absorbs filth, if it has not been prepared by taking off the sap and treating with preservative. It is a poor excuse. It has had its day and gone out of favor. Except for its noiselessness and its ease on horses' feet we should wonder why in Europe they stick to it with such pertinacity. I have also laid tamarack. It is in all respects like cedar only about three years shorter lived.

A very few words about our common "Field cobble" stone. This the most inexpensive and durable of all our easily obtainable material is despised because people are not acquainted with it. When it is given a good chance, it fills a good place. It is not well adapted for main thoroughfares or fast travel, but for yards, alleys and some ornamental work if well done it is very good and deserves consideration. It is non-absorb-

ent; it is everlasting; but to make it tolerable, the stone must be sized and pitched in good sand by an expert workman. I have seen but one job of good pitch paving in more than forty years. It is almost a lost art. To pile all sizes of stone together from 3-inch to a foot in diameter is wrong. It will sometimes stay in place fairly well and keep you out of the mud, but it is not what can be done either for smoothness of surface or appearance. If anyone present has ever chanced to see in some old country some large square or public mews of this kind of work he will readily mark the contrast made with that and our ordinary work which we put up with for about 60c per sq. yd. more or less and there is no wonder cobble paving is at a discount. I want to say a word or two about the fashion lately sprung up of making streets so flat. Even if paved ever so smooth a reasonable amount of crown is necessary to keep a street from mud. Just what the crown should be will depend on the paving material used. The rougher the pavement the more it must crown in order to carry all water to the gutter quickly. In any event it is better to err on the safe side. One in thirty will seldom be too much.

Now, about "Brick pavement," it seems to be the most promising material within our reach at present and while scarcely past the experimental stage it is sought after everywhere, dividing however with asphalt its claims for favor. Brick or block as now manufactured is a mixture of clay and shale or slag so proportioned as to show all the wearing qualities. It is as hard as iron and nearly as heavy. It seems to possess most of the good qualities and as few bad ones as any known material. Some of the blocks on the market when baked just enough to make them hard and not burnt enough to make them brittle, seem to possess everything to be desired in a street pavement to make ease of drafts, steadiness of motion. It is a downright luxury to ride over a brick pavement. There is, however, with this as with every other thing, a reverse side. It is very noisy and slippery. Its hardness and non-elasticity are very objectionable for horses' feet but is easily kept clean, absorbs no foul odors and is as perfect a sanitary roadway as can be imagined. To get this brick down in

the best manner and have a proper regard for economy is what we all want to know. Some little time ago I took a trip about Ohio to see brick pavement and methods of laying, to see how the different brands of brick compared in wearing qualities for there is a vast difference in value one over another. I shall not indicate by names the good or poor makes but will advise in buying to get them well burnt, and above all, avoid over-burning. They chip and scar and are brittle as glass. An occasional slight blister don't mean much. To prepare a foundation is where men differ. We may be pretty sure of one thing, whatever we do in concreting, the brick will follow the settlement of unsound ground sooner or later. In Ohio there is very little brick laid on concrete foundation, or have tar or grout used in the joints. The city of Sandusky has a beautiful stretch of brick pavement filled with Murphy grout, a fine piece of work, brick hardly marred a particle. It is a fine specimen of good paving. In Lima is a large square or market place in the center of the town paved with brick, down about three years with a foundation of broken stone standing to place in the best possible manner, both brick and work. Search with a broom failed to find a flaw but in some nearby brick paving, put down less than a year, we found the brick was disintegrating very bad. I saw the same thing in Tiffin. Most of the town was well paved with brick, but there was an exception. In one street the brick was not up to the mark. In this town all the foundations were of crushed stone and all keeping place well. So of every place visited the foundation was well packed and a layer of broken stone well rammed and on that one or two inches of sand cushions and no more expense made, and none seemed needed. I talked to the street committee about a layer of concrete 6 inches thick, well mixed and well tamped, to a face leaving one inch and a half for a sand cushion. This they thought unnecessary, and, judging by their work, they are right. Last year, in paving Michigan avenue in this city on 6 inches of concrete, the bridge was built during winter and spring and the filling being sixteen to twenty feet deep, settling was expected. The concrete was left out between the bridge and L. S. R. R. viaduct, and the

brick laid on sand. It has been there eighteen months and except near the bridge, where the fill of loose earth was so very deep, it stands up very well. I think we all sometimes do shollop on half-inch bass wood sheeting, metaphorically, with 20-inch spikes; however whatever be the foundation it must be compacted as deep as it is hollow or spongy. As to filling the chinks with tar, I read some specifications where the contractor agreed to fill the cracks between brick with tar mixed with thirteen per cent of asphalt, and at a temperature of twelve hundred degrees they used to boil over sometimes and burn often. That might be when the tar ran up to over twelve hundred degrees. There are very many wonderful things even to keeping tar in a kettle at a temperature five times hotter than boiling water. To do our work well is right and proper. But to proportion the means to the end, remember the end must come within the means. Man is mortal, so is his work. Even the Sphinx carries many scars. It is well to bear in mind when expending money in streets they must and will be torn up. New appliances must take the place of old and don't let us forget it, but few of the streets in new towns are in condition for permanent pavement.

I have seen so much trouble with the nasty little intakes in the gutters, I want to raise my voice against under drains unskillfully planned. Think of a man's bare arm thrust into a filthy drain all the time it rains to keep out some little obstruction, possibly a leaf or a straw. An open gutter would do the work cheaper without foul odors and no danger of clogging. But I suppose this belongs to draining.

I would like to say a little about Macadam road. I have made quite a lot of it. I don't like it for city streets. It is dusty; if sprinkled it does not seem to clean off good, and it requires a good outfit such as a stone crusher and a heavy roller and while these tools should be owned by every city their use is expensive. You are always repairing Macadam. For suburban roads they are very good. Use good judgment when you begin. If you make the road of limestone you can think what the fine dust would be, blowing in clouds, fine as snuff, ground up by the wheels. In wet weather this same dust

is a disagreeable mud. We have some half caste here put down within two years, one piece on mealy sand another on clay. The sand is naturally drained and the clay is tiled. Each is a success, though made very differently, according to the rules that we must have good stone for wear, give a good breast, take care of the water and personally watch every load. See to it that each layer is compacted by rolling till it is rolled enough, then roll for a steady business. Get the finest stone on the top two or three-inch layer and before you have it rolled enough the soft stones will crush to powder under the roller. This is no empirical business. Every piece will be a little different bottom and experience with and knowledge of the different shades of material at hand to work with, is necessary. To tell you to put three inches of coarse stone and one inch of binder and roll, then three inches of fine stone and one more inch of binder would be right in some places, but what have you to bind with? What is your bottom? How heavy is your travel? Perhaps you need a layer of flat stones at the bottom, Telford and a foot of stones on that to make a road, or your travel might as well be carried with half that expense. The way of building would vary to meet the want in each particular case. I have trespassed on your time with these disjointed remarks, written a line at a time seldom more than three or four mixed in with answering questions looking up business in every day life. I have no time to rewrite or amend. I hope I have set some to thinking. Most of you have the theory of pavement worn threadbare.

The paving round street railroad ties was discussed last year at Saginaw, and its difficulties shown up, but how to keep brick in place with light rails is still an unsolved difficulty. The deep rail on concrete seems the only thing. Many experiments made here during the past few years have each and all proved failures. It is like driving railroad spikes with a tack hammer. I hope no one will think I undervalue a good well-prepared sub-grade thoroughly drained and then six inches of concrete made with broken stones, good, clean, sharp sand, well mixed with only just water enough to moisten the mass, then so thoroughly rammed that the water shall form on the

top. On this lay not less than one nor more than two inches of good sand free from stone. This is a good foundation for brick, but what I think is unwise is to be at all this expense before the sewerage, water, etc., shall all have been put in long enough to have become firm. It is well before this work is done to make as good a bottom as the circumstances will permit, then lay the brick. It will keep travel out of the mud and if no tar has been put in the joints a little settling in the surface is remedied in surprising short time, but if tar is used it is impossible to get it off the brick, it won't burn off. This is of course a sort of calico job, its advantages are, you are getting the use of a good pavement at small cost while you are getting ready to pave, but is by no means intended to abrogate the first class work, nor is it expected to stand in Broadway, N. Y., but it will do good service in many interior towns while waiting the time for a better, as we have tested it.

Since writing the above I find in the proceedings of the Illinois Society and in the Technograph a description of Rattler test of brick, and the method of concreting fully described by diagram although I should think they use more water than is best.

MR. RIGGS: I would like to ask about this Murphy grout.

MR. APPLETON: I think it was one of the finest streets and pavements I ever saw. One of the objects in going down to Sandusky was to see that grout. One trouble there, they hadn't filled the chinks quite full enough of the grout to be level with the brick, but it was pretty near as hard as the brick; it don't chip, and of course protects the side of the brick, and I would prefer that to the tar filling. I dislike tar exceedingly because you can't get it off your brick. It won't burn off.

MR. ROGERS: What kind of a foundation was under the Sandusky pavement?

MR. APPLETON: I believe it was sand. In traveling around in northern Ohio in quite a good many towns I believe I didn't see a bit of concrete. But I don't undervalue concrete.

MR. RIGGS: I think Mr. Appleton is correct. There is very

little if any concrete used in northern Ohio. The city of Toledo has been doing a good deal of brick paving on sand.

MR. SEARS: What is the sand on?

MR. RIGGS: That peculiar quality of blue clay. We have had poor results. Franklin avenue is now about to be paved with brick on concrete, and we put on quite a thick layer of concrete. That will be the first street in our city with concrete. We are using a six-inch steel rail called the Challenge rail. We have six miles of it in Toledo, and they have it in Dayton, and with us it is giving perfect satisfaction.

MR. SEARS: What do you put under it? You must have to make your tie durable or you will have to tear up your pavement to renew it.

MR. RIGGS: We are using cedar ties with tie plate, and they have not given proper attention in some parts of the city to the foundation for the tie. The last that was laid, some of it I think the street railway company was compelled to put in a concrete foundation. But in Broadway the foundation was put in on sand, and a few weeks ago I noticed that nearly every tie had settled, and this part that was put in last summer or last spring is in the worst shape of any paving we have in the city. But so far as the track itself is concerned, we have better results from it, as the wagons keep away from the street rail and you can cross and recross it without any difficulty whatever.

MR. SEARS: I want to ask Mr. Appleton about these Ohio foundations. It seems if the foundation of sand and gravel is uniform and thoroughly consolidated, that concrete can be dispensed with.

MR. APPLETON: They haven't in any city that I know of, used concrete. I made inquiries of the street committee and city engineer in the city of Tiffin.

MR. SEARS: There is no concrete, you say?

MR. APPLETON: Not a bit. They bring their street of course to a grade and make it solid as may be; they then put five or six inches of crushed stone on, roll it and tamp it solid. There is no cement or anything of that kind, nothing like concrete,

and it certainly stands first rate, it seems to be all that can be desired.

MR. SEARS: If that is so, if the pavement preserves its uniformity and answers the purpose, why wouldn't it be a good idea to put concrete under these railway tracks in towns and dispense with the concrete on the side? It would be perhaps more economical.

MR. APPLETON: That is the very thing. You can't do anything to keep a track solid, in my opinion, until you do put concrete under your rails. In Lima I went to a hitching post, on Market square, along the pavement, which had been down three years—I disliked to come away without finding some fault, I went down there to pick a flaw—and I wanted to see about that foundation, and I found that there wasn't a brick that had settled, not a brick out of its place; the filling was sand between the brick, and I came back to Lansing firmly persuaded that you are fooling away your time with your tar and your one thing and another.

MR. SKEELS: The city of Grand Rapids put in two miles of block pavement this summer, on what we call Division street, and they duplicated some pavement that they have already, only on the west of the river it is laid on a board foundation and on the east side it is laid on concrete. That I think on the east side of the river has been down about five years—it is on Cherry street—and was laid on concrete foundation and hot tar poured on the block and then some gravel; the blocks are cedar blocks. Now you can take a hammer and go up there and strike on it and you can knock that pavement down so as to make it very uneven; dry rot, as you might call it, has decayed the lower part of the blocks. It may have been this coating of tar that stopped the circulation. I believe a green block would be better, and always have—cut it in the woods and get it into the ground as quick as you can. Now they have laid Division street in the same way. The understanding was that tar went down the whole length of the block and made a sort of a bond with the concrete. Soon they had to tear it up because they changed the street railway company's track for a half mile and turned from Division street on to Wealthy

avenue. When they did that they tore up this block, and that tar, on an average, went down about a quarter to half an inch with the exception of where there was a cavity and there it would go down a little further. Now, in my opinion, that paving on Division street will go the way of that on Cherry street. Some of those blocks that were taken out have worn down so they are only an inch and a half long. By the way, Division street was paved with block pavement just on the natural surface and smoothed off. As I said, some of those blocks were worn down, and some were nearly the full length, and you could take them in your hand and crumble them all up. Now, in order to get a good block pavement, I think it is necessary to have someone that understands the timber to sort it out, if they know which is the best.

MR. DOANE: At Belverton they make a good deal of that sapless paving, and they have cut out a good many carloads of paving that they were unable to sell and it was thrown out, but not destroyed. Times were quiet and they took posts from the river and peeled them and piled them up in the yard, and then cut them up. I understood they were shipped to Grand Rapids, and I presume that is where the Grand Rapids people got their timber from.

COL. MUENSCHER: Up in Manistee the only paving we have is cedar blocks laid on inch hemlock boards, and we have abandoned all concrete work.

MR. SEARS: Green boards on sand don't last very well.

COL. MUENSCHER: They last as long as the blocks do.

MR. SEARS: I should be afraid of that foundation, hemlock on sand.

COL .MUENSCHER: We use that entirely; we don't attempt anything else. No use to put in a concrete pavement until you are sure you are not going to tear it up. After all the sewer connections and grade connections and everything of that sort are made, then you can put in a concrete foundation; but before that time it is a waste of money.

MR. SEARS: I move that the committee on this subject be kept in the field.

MR. RIGGS: I second that motion and would like to suggest

that the committee in addition look a little further into the matter of foundations for street car tracks in streets which are paved. The question of what is the proper thing to use, whether with or without the tie plate, and what you should have under your tie, etc., it seems to me are important things. We have 94 miles of track, and these things are quite a problem with us.

MR. SEARS: I move as a substitute that the committee be discharged and that the chair be authorized to appoint a new committee.

Carried.

THE PRESIDENT: I will appoint Mr. Ames, Mr. Appleton and Col. Muenscher.

RECENT LEGAL DECISIONS.

BOUNDARIES.

1. Where, by the description of a lot in a deed, its northwest and southwest corners and its north and south lines were made to coincide with the same corners and lines of a certain survey, which were then established boundaries and monuments, these will prevail over the distance called for by the description of the east and west lines of the lot.—Fullam v. Foster (Vt.) 35 A. 484.

2. The meander lines run by the United States surveyors along the margin of the sea in surveying a Mexican grant, like meander lines upon navigable waters generally, are for the purpose of defining the sinuosities of the bank and determining the quantity of land in the grant, and not for the purpose of limiting the boundary, the latter being defined in all cases by the waters themselves. Railroad Co. v. Schurmeir, 7 Wall. 272, and Hardin v. Jordan, 11 S. Ct. 808, 838, 140 U. S. 371, followed.—Coburn v. San Mateo County (C. C.) 75 F. 520.

3. A grant by the Mexican government in California of land bordering "to the west on the sea" included only the lands above high-water mark, and not the tide lands. More v. Massini, 37 Cal. 432, and U. S. v. Pacheco, 2 Wall. 587, followed.—Coburn v. San Mateo County (C.C.) 75 F. 520.

4. A grant by the state of land bordering on a highway presumptively conveys title to the center of the highway.—Cheney v. New York Cent. & H. R. R. Co. (Sup.) 40 N. Y. S. 1103.

5. Where one of adjoining owners conveys his land to a third person, the location of the division line must be determined by the facts and conditions existing at the time of the conveyance, and cannot be subsequently shifted by an agreement to which all persons interested in the lands are not parties.—Donaldson v. Rall (Tex. Civ. App.) 37 S. W. 16.

6. Where a deed describes the land conveyed as beginning

at a certain point, and "running thence east, to the top of the bank of the Genesee river; thence southeasterly, along the top of the bank, to a point that a line parallel with the north line will contain ten acres, * * * * * * * containing ten acres, and no more,"—the course "along the top of the bank" follows the meanders of the bank.—In re City of Rochester (Sup.) 40 N. Y. S. 1007.

7. A survey after giving three sides of the tract, the first commencing at a monument, and the last ending at another monument, proceeded: "Thence [in a certain direction, and a certain distance] to ye begun bound." *Held*, that as the quantity and location of the land called for would be preserved by running that line from one monument to the other, and would not by retaining its length as stated in the survey, such length would be rejected.—Fullam v. Foster (Vt.) 35 A. 484.

8. When land is bounded on a private way, it extends only to the side line of the way.—Winslow v. Reed, 35 A. 1017, 89 Me. 67.

9. In the original survey by co-tenants for the purpose of partition, the lines between the lots were located by artificial monuments, which were hidden; but no reference thereto was made in the plat, the description of the lots therein being merely by courses and distances. *Held* that, as between one of the co-tenants and a grantee of a lot, whose deed referred to the plat for description, and who was unaware of the existence of the monuments, the courses and distances therein called for controlled the monuments.—Whitehead v. Atchison (Mo. Sup.) 37 S. W. 928.

10. A return from the board of proprietors, wherein the disputed line is located by reference to lines of other tracts, which are proved to be well established and recognized, prevails over a map on file in the surveyor's office showing a different location.—Allaire v. Ketcham (N. J. Ch.) 35 A. 900.

11. Where a line of a survey crossed a perpendicular cliff, at a place where it could not be climbed, and, to give the quantity of land called for by the survey, and to take the line to a boundary shown to have been marked in an old survey, it was necessary to exclude the distance up the face of the cliff, it was

not error to instruct the jury to exclude it in determining the boundary.—Stack v. Pepper (N. C.) 25 S. E. 961.

12. A definite boundary, like a non-navigable river, called for in a deed, controls distances and quantity in the description, and conveys the land to the thread of the stream.—Lampman v. Van Alstyne (Wis.) 69 N. W. 171.

13. Where one of the boundaries in a deed is substantially coincident with the shore of a lake at low-water mark, the intent to convey to such mark will be presumed, in the absence of language indicating a contrary intent, though the lake is not named as a boundary.—Slauson v. Goodrich Transp. Co. (Wis.) 69 N. W. 990.

14. Low-water mark on the shore of a lake, as a boundary, is ordinary low-water mark, or the level at which the water stands when free from disturbing causes.—Slauson v. Goodrich Transp. Co. (Wis.) 69 N. W. 990.

15. The boundaries of land as actually made and marked on the ground by the surveyor will control over a call in the field notes for the boundary of another tract, erroneously supposed by the surveyor to be identical with the one marked by him.—Busk v. Manghum (Tex. Civ. App.) 37 S. W. 459.

16. Where adjoining landowners agree on an incorrect division line, and the land along a portion of the line is occupied by each for a period sufficient to confirm his title by adverse possession to any land incorrectly awarded, the true, and not the adopted, line controls as the division line beyond the points of actual occupancy.—Ward v. Ihler (Mo. Sup.) 34 S. W. 251.

17. Where defendant was entitled to recover land only upon proof that the place where a quarter post had been originally set had been identified so that it was not lost, within the rule relating to relocation, a verdict for defendant was not sustained by evidence which failed to fix the point more definitely than that it was somewhere within a space covered by a circle, the radius of which was 50 feet or more. Gordon, J., dissenting.—Wilkeson Coal & Coke Co. v. Driver (Wash.) 43 P. 889.

18. Where lands abutting on a river have been surveyed by the United States government in the usual manner, so that

the lands fronting on the river are divided into 40-acre tracts or fractional lots, each purchaser of a lot or tract becomes a riparian owner of so much of the then river front as is included within the side boundary lines of his tract or lot, running to the river, and any accretions upon the river front between such lines belong to such purchaser, and are not required to be apportioned among the other riparian owners of adjacent tracts.—Smith v. Johnson (C. C.) 71 F. 647.

19. The location by the county surveyor of the section lines under act 1890, c. 35, which makes the survey presumptively correct, only makes such location prima facie evidence against the landowners.—Webster v. White (S. D.) 66 N. W. 1145.

20. The location of a meander line by a county surveyor does not establish the meander as a boundary, unless the notice and other proceedings show that such was the purpose of the survey.—Tolleston Club of Chicago v. Clough (Ind. Sup.) 43 N. E. 647.

21. Where a section line is in controversy, the line as indicated by the government mounds established by the government surveyor must prevail, when the points at which the mounds were placed have been ascertained.—Dowdle v. Cornue (S. D.) 68 N. W. 194.

22. Where the evidence shows that courses and distances in a deed differ from the monuments on the ground, or the true line as agreed upon and indorsed by landmarks, the monuments govern.—Rook v. Greenwalt (Com. Pl.) 17 Pa. Co. Ct. R. 642.

23. Which of two boundary lines fixed by different surveys is the true line is a question of fact for the jury.—Macauley v. Cunningham, 60 Ill. App. 28.

24. In ejectment between adjoining landowners, there was a dispute as to the boundary, and defendant claimed that plaintiff had acquiesced in a certain line as a boundary; but it appeared from defendant's evidence that plaintiff took no part in the selection of the surveyor who made such line, and plaintiff testified that she did not agree to such boundary, and informed defendant that she would require a new survey, and defendant thereafter attempted to prevent such resurvey.

Held, that the evidence failed to show that plaintiff had agreed on a boundary line.—Dauer v. Hildebrandt (Mich.) 68 N. W. 145.

25. A deed to plaintiff described the premises as bounded "on the north by the dugway at the north end of the horse shed." Defendant's premises, in the deed to him, were described as bounded on the south by plaintiff's land. The dugway referred to in the deed was 31 feet long and 5 or 6 feet wide at the bottom, and had apparently been cut by surface water. For many years it had been used as a footpath, and occasionally by horses and wagons. *Held*, that the dugway was a lane or alley, and plaintiff's deed conveyed title to the middle thereof.—Pitney v. Heusted (Sup.) 40 N. Y. S. 407.

DEEDS.

1. A deed contained two complete descriptions of the property one by metes and bounds along certain streets, and the other by giving the numbers of the lots and blocks according to a certain map therein referred to. The property actually sold and intended to be conveyed was correctly described by the numbers given, but was not that described by the boundaries, which was on another street, and was not owned by the grantor. *Held*, that the false description should be rejected, and that the deed constituted a good conveyance of the property intended.—State Sav. Bank v. Stewart (Va.) 25 S. E. 543.

2. An error in describing premises as commencing at a certain distance from the "northwest" corner of certain streets will not affect the validity of the deed, where the balance of the description shows that "southwest" was intended.—Heller v. Cohen (Sup.) 41 N. Y. S. 214.

3. Officers of a corporation were authorized to convey the W. 1-3 of the E. 1-2 of lots 10 and 11. The officers, after so describing the land, added, without authority, a specific description by metes and bounds, which they supposed covered the same property. *Held*, that the first description prevailed. —Novotny v. Danforth (S. D.) 68 N. W. 749.

4. A grantor, after having conveyed a right of way over his land to a railway company, conveyed to it a strip of land

described as " beginning at the north line of the A. survey, and thence south to stake No. 2,900 as put down by said railway company, the same to extend 150 feet in width west of the right of way of said railway as the same has already been granted." The right of way did not cross the north line of A. survey, as it was supposed to do by the parties, but entered the survey on the northeast line, and a line directly north from stake No. 2,900 would not touch the north line of the survey. *Held*, that the grant conveyed a strip 150 feet wide directly west of the right of way, though, due to the slope of the A. survey, it was only 97 feet wide at the north end.—Missouri, K. & T. Ry. Co. of Texas v. Waco Building & Loan Ass'n (Tex. Civ. App.) 37 S. W. 242.

5. A deed conveying the land south of a " railway cut " conveys only the land south of the upper and outer edge of the cut. —Newton v. Louisville & N. R. Co. (Ala.) 19 So. 19.

6. In construing the description in a deed which bounds the land conveyed upon a street, river, or other monument having width, courts incline strongly to such an interpretation of the language as will carry the fee of the land to the center line of such monument, rather than to its edge only.—Paine v. Consumers' Forwarding & Storage Co. (C. C. A.) 71 F. 626.

7. As the state, in Const., Art. 17, § 2, disclaims all title to tide lands patented by the United States, it cannot assert title to land situated below the line of ordinary high tide, but within the meander line, which was patented to plaintiff by the United States; said land being within the calls of the patent, and described in the official plat, and the survey and field notes accompanying the same, by courses and distances.—Cogswell v. Forrest (Wash.) 43 P. 1098.

8. When lands are described by a general and a particular description, and the two are repugnant to each other, the particular description will control, and the other be rejected as false.—Carter v. Chevalier (Ala.) 19 So. 798.

9. A deed describing land as a certain number of acres " out of the S. W. side of the C. N. Bassett survey, No. 292, of 640 acres, in Brown county," was not void for insufficiency of

description, but could be aided by extrinsic evidence.—Bassett v. Sherrod (Tex. Civ. App.) 35 S. W. 312.

10. A deed of the "west half" of a fractional lot containing less than a legal subdivision of 40 acres conveys half of the area.—Owen v. Henderson (Wash.) 47 P. 215.

DEDICATION.

1. A dedication of land is an appropriation of land to some public use, made by the owner of the fee, and accepted for such use by or in behalf of the public.—Alton v. Meeuwenberg (Mich.) 66 N. W. 571.

2. Where the public authorities refuse to approve a plat dedicating a street to public use, or to recognize the street, in the absence of a public user equivalent to an acceptance the intended dedication is revocable, as to any part of such street, at the pleasure of the proprietor and abutting owners.—Mahler v. Brumder (Wis.) 66 N. W. 502.

3. When an owner lays out a plan of lots, showing streets and alleys, records it, and conveys even one lot therein by reference thereto, such conveyance completes the dedication of all the streets in the plan to public use.—Pry v. Mankedick (Pa. Sup.) 34 A. 46.

4. To constitute a dedication of land for a highway, the owner of the land must set apart for such purpose so much of the land as he intends to be appropriated therefor, and must give it over to the public with the intention that it be used as such, and there must be an acceptance thereof by the public.—Alton v. Meeuwenberg (Mich.) 66 N. W. 571.

5. While a formal acceptance of a proffered dedication of a street is necessary before the duty is imposed on the public to repair and maintain it, such acceptance is not essential to consummate the dedication, so as to cut off the rights of the owner of the land.—Borough of Brigantine v. Holland Trust Co. (N. J. Ch.) 35 A. 344.

6. A dedication of land for a street or road need not be in writing, but may be made in any manner which clearly and unequivocally indicates the intention of the owner; and a dedication, when made and accepted, by act of the authorities or by

user, is irrevocable, and the right of the public cannot be affected by a subsequent occupation of the land by the owner of the fee, or another.—Buntin v. City of Danville (Va.) 24 S. E. 830.

7. It did not constitute a dedication to street purposes that a railroad company failed to fence its right of way in a city and permitted a portion of the public to pass thereover at a certain place.—Vicksburg, S. & P. R. Co. v. Town of Monroe (La.) 20 So. 664.

8. Where a city sells lots for business purposes running back to the commons in the rear, which remained uninclosed for several years, no presumption is thereby raised of a dedication of a right of way over such commons to the rear of the lots.—Hewitt v. City of Pulaski (Tenn. Ch. App.) 36 S. W. 878.

DRAINAGE.

1. In proceedings to review the action of a drain commissioner in deepening and widening the B. drain, it appeared that plaintiff's land was assessed for the P. drain, previously established, which has a creek for an outlet, and is crossed by the B. drain; and that the latter is 18 inches deeper, and, if deepened as proposed, will be 28 inches deeper, than the former at the intersection, and 18 inches deeper than the E. drain, which empties into the P. drain below such intersection, and was also established before the B. drain. *Held*, that the action of such commissioner was proper, as against the objection that such deepening and widening will have the effect to destroy the P. and E. drains from the point of intersection by diverting the flow of water.—Berry v. Tinsman (Mich.) 66 N. W. 579.

2. Where the lands of an owner, by reason of their situation, are provided with sufficient natural drainage, they are not liable for the costs and expense of a ditch necessary for the drainage of other lands, simply for the reason that the surface water of his lands naturally drain therefrom to and upon the lands requiring artificial drainage.—Blue v. Wentz (Ohio Sup.) 43 N. E. 493.

3. When, in an action to collect a swamp-land assessment, defendant admits ownership of the land described, the fact

that the land did not contain the acreage alleged is immaterial, where it is not shown that the assessment was levied by acreage.—Swamp-Land Dist. No. 307 v. Glide (Cal.) 44 P. 451.

4. In making an assessment on lands, benefited by artificial drainage, the extent of their watershed is not the proper rule, but the amount of surface water for which artificial drainage is required to make them cultivable, and the benefits that will accrue to the lands from such drainage.—Blue v. Wentz (Ohio Sup.) 43 N. E. 493.

5. An application for cleaning a drain, which is signed by eight persons, and recites that five of them (giving the names) are owners of lands that were assessed for benefits in the construction of the drain, and are owners of land liable to be assessed for the cleaning, and that the drain needs cleaning, is sufficient, under Pub. Acts 1893, No. 203, c. 8, § 1, providing that any five freeholders of the township, one or more of whom shall be owners of land liable to assessment for the cleaning, may make the application setting forth the necessity for the cleaning.—Angell v. Cortright (Mich.) 69 N. W. 486.

6. Landowners cannot defeat a tax for cleaning a drain where the contract was simply for the cleaning, on the ground that in performing the work the contractors increased the width of the drain.—Angell v. Cortright (Mich.) 69 N. W. 486.

SURVEYS AND SURVEYORS.

1. Gen. St. 1894, § 831, which provides that the county surveyor shall execute all surveys which shall be ordered by any court, board of county commissioners, or town supervisors, does not authorize a county surveyor, whenever a county or a town lets a contract for public improvements, the plans of which, in his opinion, necessitate the service of a surveyor or civil engineer, to do the work at the expense of the county or town, on his own motion.—Haynes v. Board of Com'rs of Blue Earth County (Minn.) 67 N. W. 1005.

RIPARIAN RIGHTS.

1. A riparian owner on the shore of the Great Lakes has no ownership in the soil covered by water, but merely a right of

fishing and navigation over the water; and therefore Pub. Acts 1895, No. 112, prohibiting, under penalty, the cutting of submarine vegetation, except for the purpose of fishing or navigation, passed in order to make a public shooting ground, is valid. —People v. Silberwood (Mich.) 67 N. W. 1087.

2. A grantee of the United States of land bordering on a non-navigable lake, meandered in the original survey, acquires, as riparian owner, title to accretions to his land resulting from recession of the waters.—Fuller v. Shedd (Ill. Sup.) 44 N. E. 286; Cleaveland v. Hardin, Id.; Thomas v. Shedd, Id.; Rand v. Hardin, Id.; South Chicago & S. R. Co. v. Shedd, Id.

3. After the grant of land bordering on a meandered non-navigable lake, the federal government cannot grant the land lying under the water or that formed by a recession of the waters, and thereby deprive the original grantees of their rights as riparian owners.—Fuller v. Shedd (Ill. Sup.) 44 N. E. 286; Cleaveland v. Hardin, Id.; Thomas v. Shedd, Id.; Rand v. Hardin, Id.; South Chicago & S. R. Co. v. Shedd, Id.

4. The title of the grantee from the federal government of land bordering on a non-navigable lake, meandered in the original survey, does not extend to the center of the lake.—Fuller v. Shedd (Ill. Sup.) 44 N. E. 286; Cleaveland v. Hardin, Id.; Thomas v. Shedd, Id.; Rand v. Hardin, Id.; South Chicago & S. R. Co. v. Shedd, Id.

37,743-1896. E.

DEPARTMENT OF THE INTERIOR,
WASHINGTON, D. C.,
April 16, 1896.

MR. J. B. HODGDON, *Galena, Kansas:*

SIR: I have received your letter dated April 2, 1896, asking to be advised in regard to questions arising in your duty as County Surveyor in the subdivision of section 12, T. 34 S., R. 25 E., Kansas, which is rendered fractional by the state boundary. In reply to the first question, the position is affirmed by you that the subdivision of the north boundary of Sec. 12 where the ¼ Sec. Cor. cannot be found should be made at distances proportionate to those reported in the original field notes. This accords with the U. S. law on the subject and

the circulars of this office dated March 13, 1883, and June 2, 1887, copies of which are enclosed for your information. The opposite view to which you refer is one often taken by persons who failed to distinguish between rules laid down for an original survey by a Government deputy and those prescribed for retracement by private or local surveyors.

Regarding the second question, it is the opinion of this office that the closing corners belonging to the section lines on either side of the state boundary, and which are found to exist at positions not in the true boundary line connecting the boundary posts, are to be accepted only as locating the *position* of their proper section lines, but not as fixing the *length* of such lines; also that the length of such closing lines must terminate on the true boundary, and new corners may there be properly fixed for the limits of lands abutting on the State boundary, in place of the identified corners of original survey.

The deputy who set such corners either failed to do his full duty, by not running to a full closing on the boundary, or else exceeded his authority by running across the line and setting a corner beyond the limits of his contract and instructions. If deputies on both sides stopped short of the State line, there would be an alleged strip of unsurveyed land where none is shown upon the plat. The United States by its patent in such cases makes an implied covenant to convey all the land to the true boundary line, and it would be against public policy to recognize a narrow strip as unsurveyed.

The State boundary was run prior to such closing lines and became the proper limit to such adjacent townships. If a deputy surveyor's corners are not truly set on such line, and they are held to be valid and unchangeable, then by his unwarranted action in setting a closing corner too far east, he would transfer a portion of the land from the east to the west township, which he had no authority to do.

A similar question has often arisen where the deputy has closed on a standard parallel incorrectly by placing his corners too far north or south. These cases seem to be exceptions to the stringent law that the original corners "must stand as the true corners which they were intended to represent, whether

the corners be in place or not." The improper placing of such a corner results in a change of the true of the standard parallel into a broken line, if the erroneous corner must be held valid. It is the opinion of this office that the true intent of the law is subserved by holding that such corners must show the true locus of the line separating the sections but cannot alter the position of the township line or State boundary; hence, that all corners of small tracts adjacent thereto should be set on the true line originally run. You asked for "the ruling in this case," but this office does not make rulings on questions like this where the lands are in private ownership and the local courts have jurisdiction. It gives advice to surveyors and land owners, but their acts are subject to state and county authority only.

Very respectfully,

E. F. BEST,

Acting Commissioner.

MICHIGAN ENGINEERING SOCIETY.

Annual Convention and Business Transactions.

The 18th annual convention of the Michigan Engineering Society was held at Lansing, January 19 to 21, 1897. In behalf of the mayor of Lansing, Mr. A. O. Bement welcomed the society to the city in the following words:

Mr. President, Gentlemen of the Society: It is rather embarrassing for me to represent the mayor on this occasion, although I am very glad to represent the city of Lansing. The mayor wishes his apologies offered as he was obliged to be out of the city and could not be here. I know he would have been very glad indeed to have given you some of his ideas on engineering. He is a man of a good many ideas, and one year at the head of the city government has given him a notion that there are a good many things that a mayor ought to know, especially I know he studies the question of the government of cities a good deal, and seeks to know the best methods to secure the best results.

To my mind the engineer is the most important man that can be connected with city government, and I believe we are beginning to realize that more than ever.

The fact is, we are here tonight to offer you the keys to the city of Lansing, but we want you to be a little bit careful about going around the back ways and unlocking doors which we do not want unlocked. It is probable that you might fall into a sewer that is in bad condition, or get into some of our net work of drains, and it might perhaps puzzle you a little to know how they got there, and why.

As I have said, to my mind one of the most important things in the government of a city is the engineer, but unfortunately for us we are not always able to engage the best talent in the government of our cities. I suppose the time will come when the engineer of a city shall be appointed, not because he has a political pull, but because he has ability. We have found in

our experience that there are two kinds of engineers. There is the theoretical engineer and the practical engineer, and I have an idea that probably (without casting any reflections upon the profession at all), that occasionally there are young engineers who like to practice on towns about the size of Lansing, and it is usually at the expense of the towns. I have come to the conclusion in my short experience that it is money well expended for every city to have competent engineers, and men who have practical knowledge of what they profess to know. The engineer of every town like Lansing should not only know how to build sewers, but he should know how to pave and know how to build bridges, and a thousand other things that the theoretical engineer knows nothing about.

We have had a little experience recently. For some time, in discussing our pavements, the question has been referred to the engineer as to what kind of pavement was best, what kind of brick, if we should use brick, what kind of foundation, if we should have a foundation, and all these question had to be settled on the experience of some man who is an engineer. And it seems to me that the time is coming when municipalities are bound to see that an incompetent engineer is one of the most absurd things that can be foisted on a city. Our friends across the water know a great deal more than we do, and we ought to be governed largely by their experience. For instance, we know that in Germany a man is called to be the mayor of a town, not because he is a resident of the city, not because he belongs to any party, but because he is competent to govern a city and to direct its movements. It seems to me that a municipality should govern itself in the way that you would take care of your individual business, in a business way, and that an engineer should be selected because he knows what he is talking about, knows his profession, and knows what are the requirements of a man in that profession. I have no doubt that the time will come when we shall be able to engage engineers on that theory, that they know their business, and because they are experienced in it.

I did not come here tonight, gentlemen, to make any speech at all, but to welcome you to Lansing, and say to you that we

feel very grateful to have you in our midst, and we trust that you will enjoy yourselves and make yourselves at home in Lansing's borders.

THE PRESIDENT: Mr. Bement, every member of this society is glad to hear these words of welcome. We, as a society, feel a great interest in your city, and we have held, I think, fully one-half of our meetings here.

The matter of city engineers is one of a great deal of importance to the public as well as to the profession, and it is gratifying to hear a gentleman connected with city government who appreciates this as you have expressed here tonight. I think I san say without fear of contradiction that the element of politics in municipal engineering has driven a great many men from that line of work. They would prefer to ally themselves with some corporation or business house in need of an engineer rather than give their services for a time which they would not be sure of to a municipal corporation. They have in many cities, put the city engineering more upon the plan of common laborers than they have as a profession; and indeed in many places a man of very little skill in other lines would receive about the same salary from a city government as an engineer who would have to bring with him some experience and a great deal of technical knowledge of his work. Again, I say it is gratifying to hear the position that you have taken tonight by a gentleman conversant with municipal governments. Our society discusses questions of a public nature, and you and the citizens of Lansing are cordially invited to attend all of our meetings and take part in the discussion.

President Wells opened the session of the convention with the following address:

Gentlemen of the Michigan Engineering Society:

I wish to acknowledge the compliment which you have paid me by again choosing me as your president. I want to thank the members of this society for their cordial coöperation in advancing its interests.

We may take a pardonable pride in the work of the society and in the production of our annual, and without in any manner depreciating the work of similar societies, we can feel that

a comparison will not show that our work has been of second rank. There are indications in them that the members truly appreciate the advantages of the association and are endeavoring to have the society accomplish what it was organized to do—to render mutual aid and to encourage uniform practice.

There are some matters to which I believe the attention of the society should be called. In article I of our constitution three grades of membership are described: senior, junior and honorary. The by-laws provide for the election of the first two grades, but there is no provision for the election of honorary members. In framing a by law to provide for election of members to the honorary grade, proper safeguards should be incorporated in it so that honorary membership will mean what the name implies. Would it not be well to have nominations for membership to this grade made by the board of directors and election the same as for other grades? Would it not be well, also, to limit the number of honorary members who could be elected outside of those who might become eligible through a continuous active senior membership? I trust that the proper filing of the notice of the amendment to the by-laws, as provided in section 9 of the by-laws, will be made at this meeting.

In view of the fact that the bill in congress for the adoption of the metric system of weights and measures was lost, only by a small majority, and to encourage the friends of the measure, it would be appropriate for this society by resolution to make some expression of approval of legalizing that system which will do away with so much labor as is involved in the old standards.

In that very interesting little "Basket of Chips" which Mr. Skeels presented to us at our last meeting, he suggested that a banquet be held at our meeting in 1899 to commemorate the 20th anniversary of the society. It is two years off, but it takes a long time to arrange anything of this kind among members scattered so far apart as we are, and the correspondence necessary to arrange such an affair a few months before its occurrence would involve a great deal of labor—more labor than any single member would care to devote to it,

I fear. If the matter is talked over at this meeting, some definite action taken, and the accumulation of the fund suggested begun, at the end of the two years we will have found that we did not begin any too soon.

The use of a common datum line by all the engineers in the State has been a matter of interest to me for a number of years. The solution of problems of water supplies, water power drainage, railroad location, location of "Good Roads" and electric railroads, etc., etc., would be greatly facilitated by accurate contour and topographical maps. If a united effort was made by all the engineers in the State to use a common datum line, there would soon be in existence sufficient information to permit a reliable contour map to be published from which we should be able to derive much benefit. I have been able to talk with a few members of the society about this, and the idea has met with warm support. Through the untiring efforts of Mr. Sears, we have here a number of profiles of the railroads of the State. If these are published they will give the means of establishing bench marks with a common datum.

If the members of the society would use a common datum in their future work, and have some system of making a map record of elevation at some convenient point like section corners and quarter posts, which would be reported to some committee, or if they would go still farther and trace in on the map contour lines indicating differences in elevations of 10 feet, in the course of a few years we would be able to get out a map of incalculable value.

The address was referred to a committee of three, H. E. Riggs, D. Skeels and C. C. Pashby, to consider its suggestions and report their recommendations in regard to them. Later in the session they made the following report:

Your committee appointed to review the president's address beg to report as follows:

The suggestions of President Wells are all practical and valuable. We would favor the following action:

First, The by-laws of our society should be amended so as

to provide a suitable standard for election to the grade of honorary member.

We would recommend that the directors be requested to draft suitable amendments to the by-laws and submit the same to the society at its next annual meeting.

We would recommend that the grade of honorary membership be limited to senior members of this society who by reason of active and earnest work for this society shall have earned the rank of honorary member, and who on account of age or other reasons shall desire to lay aside the active duties. Such members of the society should be eligible. We would also recommend that not to exceed ten prominent engineers, not members of this society, may be elected to honorary membership. We believe that all proposals for the rank of honorary membership should be made by the board of directors, and election made by letter ballot as in the case of the other grades of membership.

WHEREAS, The Michigan State Engineering Society recognizes the superior advantage of the metric system of weights and measures; and

WHEREAS, The bill providing for the adoption of the system in all transactions in the United States failed of passage by only a slight majority in the last session of the present congress;

Resolved, That this society earnestly requests that the Michigan delegation in congress work with renewed effort for the passage of the bill; and

Resolved, That a copy of these resolutions be spread upon the minutes of the society, and that one copy signed by the president and the secretary be submitted to the senior United States Senator of the State, and that a similar copy be transmitted to Wm. A. Smith of the 5th congressional district.

Your committee would recommend that the society celebrate the twentieth anniversary of its foundation by holding a banquet and social at the time of the annual convention in 1899. We would further recommend that a contribution of 25 cents in addition to the annual dues for the three years, 1897, 1898 and 1899, be solicited to defray the expenses of such a recep-

tion and banquet. A committee should be appointed one year hence to make local arrangements, and a committee should be appointed at this session to arrange for an address at the anniversary by some practical engineer of wide experience on some topic of general interest to the society, and also to provide other literary and musical features for the occasion.

We recognize the value to engineers and surveyors of this State of a uniform datum plane. The work suggested by President Wells involves a vast amount of work and the expenditure of considerable money. The first step in the matter would be the tabulating of elevations of principal points on the profiles of the railroads which are in our hands. These should show the elevations of all summits of grades, all rivers (where attainable), suitable points in each city or village, and all railroad crossings. The elevations of railroad crossings appears to your committee to offer a convenient check on levels, and an opportunity to reduce all levels to one common datum, which shall be sea level, or the level of Lake Michigan. If members of the society will volunteer to commence this work, we believe it may be extended, and in the future perhaps be made of practical value. We would not favor any expense in this work at present. The amount of the work is so great that no one man can undertake it for glory. The work if done at all must be divided among a number of members.

H. E. RIGGS,
D. SKEELS,
C. C. PASHBY.

The report of the committee was accepted and each of its recommendations adopted.

The Thursday session was held at the Agricultural College, to which place the society was welcomed by Prof. Weil. He said:

We are only too glad to welcome you here, and glad that you have made yourselves so informal and so much at home. Unfortunately, Pres. Snyder could not be here, and the duty devolved upon me to welcome you.

I have great pleasure in welcoming you to the halls of this

institution, and would say that your coming among us gives us the assurance that we have some hold on the engineering world. And further, we feel assured that if we have such relationship with the engineering world, that it is in no small measure due to the efforts of such men as Prof. Carpenter, Prof. Durand, and many of our friends who are associated with you in your society. We have here, as some of you know, but I am confident some of you do not know, three courses.

The engineering work is carried on in three departments —mechanical, electrical, and civil engineering. I must state here very specifically that there is no other engineering course than the mechanical course, the civil engineering course and the electrical engineering being incidental to the mechanical course. Now we invite you, if time permits, to visit the various class rooms and laboratories where the work of these courses is being carried on. I do not doubt you would be very much interested in the model kitchen and the dairy. Food is the prime necessity of life from a material standpoint. However, it is the engineer that has made it possible for one farm to produce today food for 250 people, when forty years ago it could only produce for thirty people. Therefore, we particularly request that you will not fail to visit those laboratories, and the engineering laboratories where is going on the work of training young men for that profession which counts among its members the greatest economizers of material wealth.

Further, we invite your criticism, your kindly criticism based on observation and a true knowledge of the situation. This will help us, as by this criticism you will coöperate with us in our work.

Now, we thank the engineers for coming out here and bringing so powerfully before our student body the value of these meetings to professional men. We feel that it may be that not only is this point necessary to be brought out for the students by you, but for some engineers in practice as well. We take it that they may not appreciate fully the value of such meetings and also perhaps realize the efforts necessary

on the part of those who carry on and bring to a successful issue these meetings. These meetings, in my opinion, are really market places for the interchange of ideas and knowledge born of experience.

I would say that in the past year, the bad year of 1896, American manufacturers exported over twenty-one million dollars worth of machinery, while the people of the United States imported something less than three million dollars worth, leaving a balance in favor of American machinery of eighteen millions of dollars. What was the cause? In my opinion the answer is found in a statement recently made that the American manufacturer owes his success undoubtedly to the fact that the American is unceasingly throwing away old and worn out machinery and replacing with new and improved types. Now, it is just so with the engineer, in my opinion. It is necessary that he should throw away the old false ideas, modify his ideas, gain knowledge of other facts and new ideas, and there is no better place to modify ideas, get new ideas and enjoy this knowledge that at such meetings as these, and especially during the informal discussions and talk among the members.

I wish to call the attention of this society to the desirability of educating engineers for the navy in our civil schools. I just mention this incidentally because I think it is time the schools took some action and paid some attention to this question. This is now being considered by the leading educators and the engineering journals throughout the country. I think it deserves the attention of all engineering societies, and especially the Michigan Engineering Society, when you consider the location of our State.

One more point and I will not interrupt your proceedings any further. I had not intended this morning to say anything about a technical education, but certain sounds that have reached my ears make me feel inclined to say a few words concerning a technical education, and particularly a technical education at the Michigan Agricultural College. There seems to be a current of feeling in the society against technical education, though I trust only an upper current, not an under

current, and I wish to say a few words about technical education, and particularly the technical education of engineers and the practical education of engineers. When Mr. Wm. Kent addressed us last year at this place, he said—and I believe it—that engineering schools need no defense, their purpose and position is fixed, and I agree with that sentiment. I believe further, that the engineering course at the Agricultural College needs no defense; I believe its position and its purpose is secure. It is not for us to say whether it needs criticism or not. Our hope is in our graduates. Our course is young, only starting in 1886, but we believe that we are growing through our graduates. The graduates of any engineering school are few, because many are not fitted to complete the course. The engineering school here has a peculiar function, as you are aware; it reaches a class that the University of Michigan will not. The University has its place, and we have ours. There is a class of men who, if they did not come here to this school, would go to no school. They cannot get into the University, they are not prepared for it, but they are prepared to enter this place, when they can afterwards go to the University or some other higher school. I say that our hope and our trust is in our graduates. The small body of men who go out from here are going to do engineering work; we will find them there. It is not an uncommon thing—it has happened several times—that a man who has completed our course has gone from here to Cornell University and completed the course of engineering there in one year. With regard to our graduates, I will say that during the past few months, in one of the large offices in Chicago, one of the largest corporations in the country, all of the draughtsmen were laid off but one, and that man was a '93 graduate of this school.

Perhaps I have said enough for ourselves. Much credit is due to our past professors, Carpenter, Durand and Breckenridge, and we are trying to keep up the standard set by these men. We believe there can be no question about the character of work that has been done under those men, and we ask

you to take a true interest in this school and lend us your kindly criticism.

We thank you for coming among us, and assure you that if you will visit the various laboratories you will receive a most cordial welcome.

THE PRESIDENT: Prof. Weil, we are very grateful for your cordial welcome to the society, and I am sure that every member of this society, whether he is a graduate of this institution or not, or whether he is a graduate of any other institution or not, is interested in the Agricultural College. There has been considerable said at this meeting about practical men and theoretical men; graduates and non-graduates of technical institutions. Perhaps I might say a few things in regard to that, and if I make any personal reference to myself I hope you will pardon me. I cannot be classed as a school man. I graduated from the Cleveland high school at 19 and associated myself with an old practitioner. I have been in practice for about fifteen years, and the result of that practice has taught me that the natural and logical course is for a man to take a technical education before he gets into practice. Theory is perfected imagination, and a man without a perfect imagination has no business to be an engineer. A technical education to a man who devotes his life to a profession, is a matter of economy, economy of time; and if a young man would ask my advice on any course to prepare himself for the engineering profession, I should by all means advise him to take a technical education or course before he entered practice at all. Otherwise, it means devoting many hours of hard work which a man really ought to devote to, say the social side of life; it robs him of all that time. A young man graduated from a technical school say at 23 cannot be expected to possess all the knowledge of an old practitioner, and whether a young man of 23 has had his training in a practical way or a theoretical way, he is by no means competent; if he were, it is time for him to die. But we ought not to criticise young men unduly, whether their training has been all of what is called practical or theoretical; give them a chance. But, as I said before, the natural and logical way for

a young man to prepare himself for the engineering profession is, if he can by any means, to take a technical course first.

The following resolution relative to the State educational institutions was adopted:

Resolved, That the Michigan Engineering Society hereby expresses its high appreciation of the technical training furnished by the great educational institutions of this State, the University of Michigan, the Agricultural College, and the Mining School, and earnestly recommend to all young men who have any branch of engineering in view as an occupation, to avail themselves of the advantages offered by these institutions.

By invitation of the society Doctors Baker and Wilbur attended the Thursday session and took part in the discussions. A vote of thanks was extended to the officers of the College.

The business meeting of the society was held Wednesday evening and the following business transacted. The reports of the secretary and treasurer were read and accepted as follows:

SECRETARY'S REPORT.

To the Board of Directors of the Michigan Engineering Society:

I would respectfully report the following business transacted by me for the society since the last annual convention: Immediately after the convention I let the job of publishing the Annual to the Kalamazoo Publishing Company, 1,500 copies at 95 cents per page. The work was promptly done and before the end of May copies had been sent to every one of our members who was not in arrears for dues. Only two papers in the secretary's hands were omitted, one of which by Mr. Ames was withdrawn by him for use with additions on a future occasion. Some illustrations were omitted which would have been used but for uncertainty in regard to funds to pay for them. Some of the advertising was not secured until after the work was ready for the binders, causing extra expense for its insertion. The secretary believes that work of securing advertising should begin earlier in the season. Three new exchanges have been secured during the past year,

the publications of the School of Practical Science, Toronto, the University of Tennessee, and the newly formed Society of Surveyors and Engineers of Minnesota. A similar society has been formed in Wisconsin, which will probably publish a report next year and with whom I have corresponded relative to an exchange. I hope to be able to effect other exchanges so as to bring the circulation of our report near 2,000 another year. With increased circulation we should be able to increase our advertising patronage as well as our rates. I have received the following exchange reports for 1896: Connecticut, School of Practical Science, Iowa, Technograph, Minnesota, and University of Tennessee. The following members are two years or more in arrears for dues. They have all been notified as required by by-law 6, viz.: Messrs. A. L. Drew, J. W. Holmes, Jerome Allen and John McLoughlin.

Mr. T. P. Whittier, who was elected a member last spring, has not paid the membership fee. His attention has been twice called to it. According to by-law 3 his membership should be declared forfeited.

Ballots on the amendments to the constitution were sent out to all the members, together with the ballots for members in March last. The ballots are herewith returned to be canvassed. Ballots for officers were sent out August 16 and are herewith returned for canvassing.

When the Annual was being published, 750 reprints of Messrs. Hazen's and Williams' papers were published at a cost of $17.25; 200 of these were given to Mr. Hazen and 250 were sent to Mr. Williams. I have sold others to the amount of $11.25, and have the remainder on hand. Nearly all of those sold went in a single order to Jersey City.

F. HODGMAN.

TREASURER'S REPORT, 1896.

To the Board of Directors of the Michigan Engineering Society:

I would respectfuly report the following sums received and

disbursed by me for the society for the fiscal year ending September 15, 1896:

Receipts.

Balance on hand at beginning of the year.	$186 26	
Received from advertisers in 1895 Annual.	125 88	
Received from advertisers in 1896 Annual.	291 50	
Received from annual dues from members.	338 75	
Received from application and membership fees	53 00	
Received from Annuals sold	41 65	
		$1,037 04

Expenditures.

Paid for Annuals and other printing	$515 28	
Paid to secretary as voted by the society	125 00	
Paid to stenographer	88 00	
Paid for envelopes and postage stamps	48 74	
Paid expenses of secretary	25 04	
Paid expenses of board of directors	21 29	
Paid express and freight	13 69	
Miscellaneous expenses	21 00	
Amount on hand Sept. 15, 1896	179 00	
		$1,037 04

There is an unsettled account with the Kalamazoo Publishing Company for manufacturing the 1896 Annuals and other printing amounting to about $50, which is referred to you for your consideration. This, with a small bill of $2.75 at Robt. Smith & Co., covers the entire indebtedness of the society.

There is due it from members for one year's dues	$69 00
There is due it from members for one year's dues and over	32 00
There is due it from members for two years' dues	30 00
There is due it from members for reports sold	28 00
There is due it from advertisers	41 00

Of these accounts those for dues more than one year in arrears may be considered practically worthless.

F. HODGMAN,
Treasurer.

Subscribed and sworn to before me, a notary public, in and for Kalamazoo county, this 15th day of September, 1896.

WILBUR C. POND,
Notary Public.

SECRETARY'S REPORT OF THE ANNUAL MEETING OF THE BOARD OF DIRECTORS.

The annual meeting of the board of directors of the Michigan Engineering Society was held at Hotel Downey in Lansing, Wednesday, September 16, 1896. There were present Secretary Hodgman and Directors Appleton and Skeels. The secretary's annual report was read and approved. The treasurer's annual report was also read and approved. The membership of Jonas Allen, A. L. Drew, J. W. Holmes and John McLoughlin were annulled for non-payment of dues. The membership of T. P. Whittier was declared forfeited for non-payment of membership fee. The secretary was authorized to settle with the Kalamazoo Publishing Company on his own judgment of what was fair and right. It was voted to hold the next annual convention in Lansing, January 19, 20 and 21, 1897, and arrangements as far as possible were made for it. The ballots on the proposed amendment to the constitution were canvassed and the amendment declared adopted, there being only one dissenting ballot. The ballots for officers were canvassed and the following declared elected: President, Geo. L. Wells; vice president, Frank F. Rogers; secretary and treasurer, F. Hodgman; directors, Dorr Skeels, Wm. B. Sears and Chas. E. Greene.

The dues of two members were remitted because of poverty and ill health.

The board then adjourned.

F. HODGMAN,
Secretary.

It was voted to pay the secretary $175 as compensation for his services during the past year.

The committee on effect of frost on cement mortar was discharged.

It was voted to continue the committees on forestry and on the relation of sewerage and water supply to the public health.

Nominations for president for the ensuing year were made, of which all declined except Mr. Frank F. Rogers. Other nominations were as follows:

For vice president, J. J. Hubbell, C. C. Pashby.

For board of directors, C. E. Greene, A. J. Teed, Dorr Skeels, J. J. Hubbell, E. Strong, Wm. B. Sears and H. K. Vedder.

For secretary and treasurer, F. Hodgman.

The thanks of the society were voted Mr. Wells for the efficient manner in which he has performed the duties of his office. It was voted to be the sense of the meeting that the next convention be held at Port Huron.

A social meeting followed on Wednesday evening at which various toasts were responded to and music was furnished by the Climax Male Quartette, consisting of the Carver Brothers, F. Hodgman and Geo. W. Lynn. Appreciative resolutions of thanks to the quartette were passed by the society and their expenses ordered paid.

A special meeting of the board of directors was held Thursday at which the following applications for membership were considered and approved:

For Senior Members.

Chas. L. Weil, Prof. Mech. Eng. Agricultural College, Mich.

A. L. Westcott, Inst. Mech. Eng., Agricultural College, Mich.

H. E. Terry, city engineer, Saginaw, Mich.

R. W. Hawley, irrigation engineer, Ft. Collins, Colo.

Harlan K. Whitney, surveyor and engineer, Battle Creek, Mich.

C. S. Sheldon, draughtsman, Grand Rapids, Mich.

R. S. McCormick, civil engineer and draughtsman, Battle Creek, Mich.

C. E. Hendrick, chemist and mining engineer, Ishpeming, Mich.

Harry Hodgman, surveyor and civil engineer, Amherstburg, Ontario.

T. W. Barrally, civil engineer, N. Tonawanda, N. Y.

Jesse B. Snow, civil engineer, Tonawanda, N. Y.

These were submitted to the society by letter ballot and all the candidates duly elected April 6, 1897.

RESPONSES FROM THE SOCIAL MEETING

THE MICHIGAN ENGINEERING SOCIETY.

F. HODGMAN.

Mr. President and Gentlemen of the Engineering Society:

It will be impossible for me in the few minutes at my disposal to say more than a very small part of what I should like to say upon the topic assigned me, so I will content myself with giving the barest outline of the origin of the society—what it has done, and how it stands today. Its original promoters were Mr. J. E. Sherman of the State Land Office and Prof. R. C. Carpenter of the Agricultural College. At their instance a call was issued by fourteen persons, of whom I was one, inviting the surveyors and civil engineers of the State to attend and take part in a meeting to be held in the State Capitol March 24, 1880. Seven of the signers of that call are now members of the society. The meeting was held and a permanent organization effected with Prof. C. E. Greene as president and J. E. Sherman secretary. Aside from the work of organizing, the meeting was devoted almost wholly to the discussion of questions pertaining to land surveying and the county surveyor's office. A committee was appointed to prepare a Manual of Land Surveying which should answer questions not treated in the text books. There were 63 members enrolled at that meeting, not all of whom were present. Of that number ten have passed over the river and eighteen retain their membership at the present time. Of the remainder, some failed to renew their membership when the society was incorporated, some have withdrawn and the rest have been dropped from the rolls for non-payment of dues. The society was originally named the Michigan Association of Surveyors and Civil Engineers. During the earlier years of its existence the papers and discussions were chiefly on questions relating to land surveying and every important phase of the subject was handled. The Manual of Land Surveying was issued in 1886. Just before this time questions of civil and

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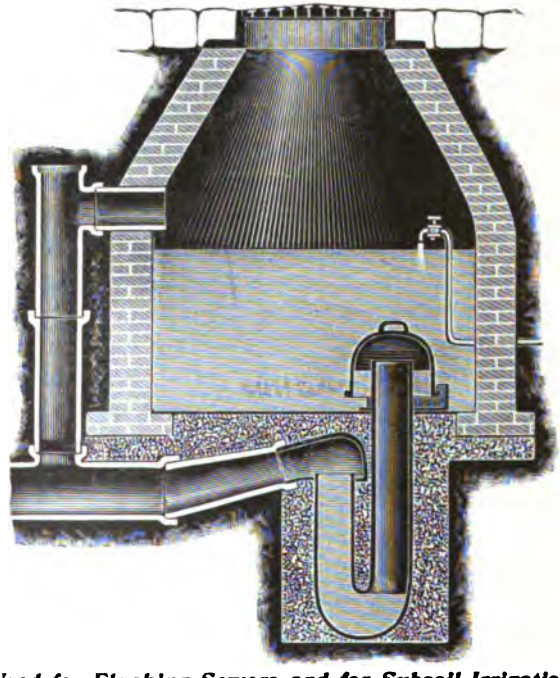

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Gentlemen: We placed six of your Miller Automatic Siphons in our Ninth and Tenth Ward sewer systems, built last Fall, and *they are giving excellent satisfaction.* These siphons consist of but two pieces of cast iron, with no movable parts, and I can see no possible chance for them to ever get out of order.

Signed. F. F. ROGERS,
City Engineer.

sanitary engineering came to the front and the name was changed to the Michigan Engineering Society. Then it became evident that if the society was to be permanent it must have a legal standing and responsibility, be capable of enforcing its laws, of collecting dues and assessments from its members, of suing and being sued in the courts if necessary. To this end it was incorporated in 1888. Since that time it has not made any net increase in its membership, but it has made rapid progress in the amount and value of the work it has done until now it will compare favorably in these respects with any engineering society anywhere. The Manual of Land Surveying, issued under its auspices, has passed through six editions and the seventh is in press. It has done more than all other text books together to bring about uniform and correct methods in making surveys and resurveys under the United States land system. It stands as an accepted authority in the General Land Office at Washington and in many of the highest courts of the land. Aside from this the society has published nearly 2,400 pages of reading matter in its Annual, of which 300 pages are on land surveying and kindred topics, 186 pages are on roads and pavements, 155 pages on water works and sewerage, 130 pages on railroads, 100 pages on bridges and 900 pages on miscellaneous topics embracing almost every subject connected with the profession. Aside from our own publications, we have exchanged with other societies until we now have on our list 14 exchanges by which each member gets annually from 1,500 to 2,500 pages of engineering literature, discussing questions in every branch of civil engineering. The expense has been merely nominal to the members. All this has been accomplished by the untiring efforts of a comparatively small number of our members, men who like our honored president are ready and willing to put a shoulder to the wheel at any time; men who see the things that are needed to be done and do them. Since the society was organized there has been paid into its treasury about $7,500. It has paid every obligation promptly when due, has always had a small surplus of money on hand and has lost many hundreds of dollars rather than enforce its rights

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Do you want to see a list of tests? Write us for a paper weight.

ALL KINDS OF PIPE IN STOCK
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against members who were either unable or unwilling to pay their annual dues. It is an educational institution and the men who do the most of the work are the ones who get the greatest benefit from it. No man can prepare a paper for discussion in the society without himself gathering and putting in order new ideas or gaining a clearer conception of the subject than he had when he began. We are becoming broader minded and deeper thinking men with each successive meeting. The land surveyor has learned something of railroad and city engineering work and the railroad engineer has learned how to subdivide sections and restore lost corners of the United States surveys. Both have learned something about sanitary engineering. So I might go on and enumerate particular after particular in which each one of us is a broader minded better man for belonging to our society, especially if he has done his share of its work. The young man's education has been taken up where the schools laid it down and it has been carried on by clear headed, practical men who knew by experience whereof they spoke. As the society has grown in capability and usefulness the young men have grown with it and they too have become clear headed, practical engineers whom we all delight to honor with positions of trust and responsibility. May the good work go on until every member of the society is not simply an absorbent, taking in the fruits of other men's life work and experience, but ready at all times to give something of his own in return for what he receives.

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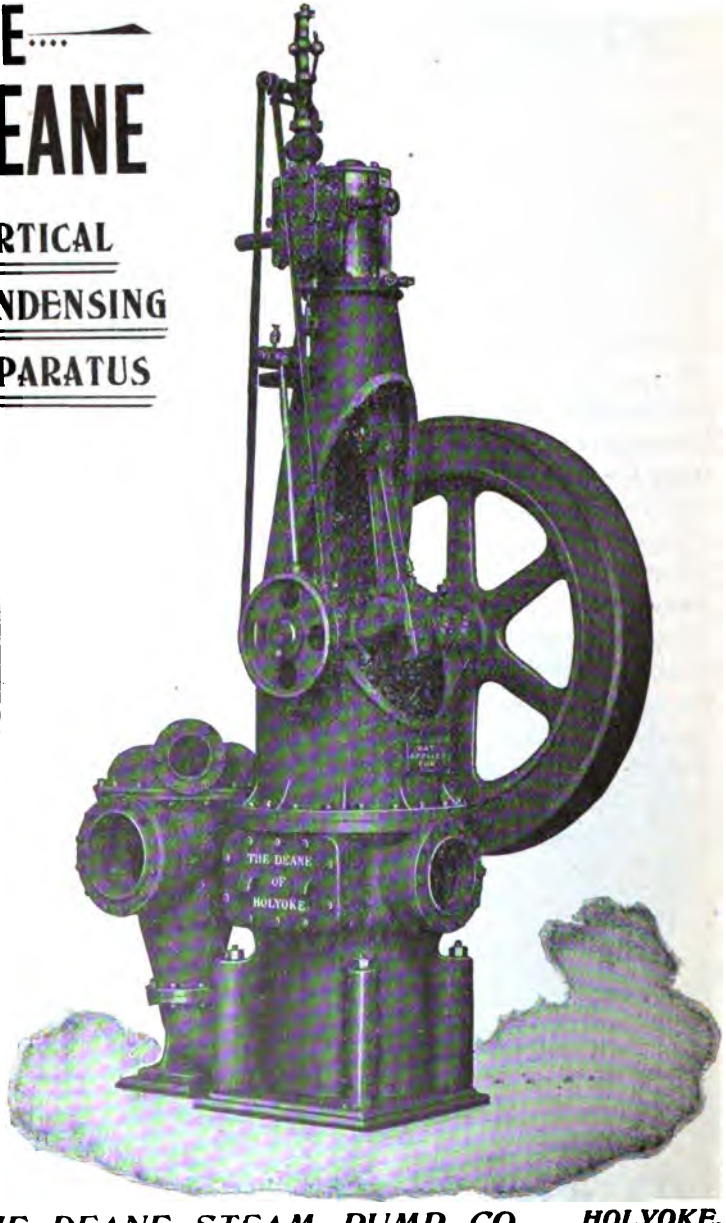

THE DEANE STEAM PUMP CO., ***HOLYOKE, MASS.***

WRITE FOR 1897 CATALOGUE.

THE SURVEYOR THE ADVANCE GUARD OF CIVILIZATION.

DORR SKEELS.

There are surveyors and surveyors. The surveyor is not a saint; he is not a profane being. Many a weary tramp, many a cold, wet bed have been his. When out in the rain all day, everything but pocket compass and matches thoroughly soaked—by the way, his feet never get wet for a hole in the toe of each boot lets the water out as fast as it comes in at the top—as darkness begins to show he does not sit on the trunk of a fallen tree and curse all things knowable, but, whistling, hustles together material sufficient for a rousing fire during the night, chews the birch twig, holds converse with the owl and the wolf. As soon as daylight shows he goes to camp. On the forked stick he roasts his salt pork, goes about his day's duties, happy, and if the careless axeman cuts the brush so that in falling it comes on his instrument, or that man with the inquiring mind steps up with his old jackknife and wonders if it will attract the needle, he does not get mad and swear. He simply and quietly then and there, in a supremely effective manner, administers the damnedest damned damning that the moral code of the surveyor allows.

The surveyor that has been in the harness forty years has stored away many adventures, experiences and anecdotes, which, if compiled, would be interesting reading to many. One will suffice on this occasion. A great many moons ago a man of means and more than ordinary intelligence came into the office saying "You are the surveyor?" "Yes." "I have here the deed to 160 acres of land somewhere in Michigan; I thought when I got at Grand Rapids I could get a horse and wagon and drive to my land, but I find I do not know anything about it. Can you find it for me?" "I can." We went by railroad as far as we could and then struck off into the woods some five

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miles. His description was the southeast quarter of an interior section. We came to the southeast corner of his land. There on a beech tree, were the town, range and section, the same characters that were in his deed with the exception of "southeast quarter." He was very much surprised. We marked anew the south and east lines of his land, stayed with him over night, and in the morning marked a trail out for him. As we were leaving him he took our hand, saying "Mr. Surveyor, when I left my home away back in the east I was given an entertainment and called a pioneer; but do you know, sir, you surveyors are in fact the great pioneers, the real advance guard of civilization?"

If it be true that "an honest man is the noblest work of creation," then the surveyor is a most noble man. Massive in strength, surpassing in sense, in mental force subduing, and as transparent as the crystal in straightforward honesty. His perceptive and receptive faculties are of a very high order; he takes impressions and knowledge from all sources. What he obtains he holds and draws upon at pleasure, nothing being too insignificant for him to investigate.

He is a leader, has the power to overcome obstacles, always self poised, cool, positive, ready for action, has an intense sense of justice between man and man, equal to every emergency, never doubting, ever confident, adorns the time in which he lives with honorable, noble works, durable contributions to human progress which cannot perish. Honesty, stability, integrity and moral rectitude rule his spirits; are an antidote against corrupt poisons of all natures. Names and definitions may sometimes be vague and varying, but principles are immutable. Who is he "to true occasion true, that tower of strength which stands four square to all the winds that blow," that goes before, the lead of the great tide of civilization, settlement and progress,—the pioneer, the advance guard of civilization,—blended into a one noble whole, THE SURVEYOR.

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DESIGNING THE ENGINEER.

PROF. C. E. GREENE.

Mr. President, Ladies and Gentlemen:

It is very kind of you to give me an opportunity to speak on this subject, and also kind of you to ask me to speak first, for I have a clear field, which enables me to say what I please, and I shall the sooner enjoy the satisfaction of a duty performed.

Pausing before attempting to *design the engineer*, one is interested to know what an engineer is, so that the plan may be laid out in the proper manner. I saw, in a recent number of a technical paper, a letter which you may not yet have seen, and, as it throws light on what an engineer may be, with your kind permission I will read it.

"In regards to the construction of the water works at ———— built by me they are on the same principal as I build all the double plan of my own. I warant all my works not to leak or freeze in the coldest climate. I do all the principal parts myself. I seldam work by plans having all nesary plans in my head and hands for as soon as I go over the ground I know what is required and the cost within ten dollors either way having been in the buisness forty years. If I construct any works under any other Engineer I have Invariably got to alter the plan of work so as to a better advantage of same works.

"I am the oldest Expert water or gas works builder on this continent and being a practical workman as well as a Engineer having built some of the largest works in Canada. Besides quite a good number in the U. S. having testimoials from them refrance given if required. You can publish this in part or whole as you may think fit."

Evidently the editor of the paper took the writer at his word, for the name and address were added. If the engineer to be designed is such an one as just described, the task is not

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Their instruments are in general use by the U. S. Government Engineers, Geologists and Surveyors and the range of instruments as made by them for River, Harbor, City, Bridge, Tunnel, R ilroad and Mining Engineering, as well as those made for Triangulation or Topographical Work and Land Surveying, etc., is larger than that of any other firm in the country.

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for any of us; no technical school is required for the self-made man.

But what is an engineer? There is hardly any branch of human knowledge, any application of science with which he may not be concerned. He must control the forces of the wind and of the falling waters, so that they may be employed to grind our corn and weave our cloth. He deals with the making and perfecting of machinery for the conversion of materials and the distribution of supplies. He builds roads and bridges by which communication is facilitated; canals, docks and harbors in which ships may be received, to transport to the ends of the earth the products of vast industries and to bring back raw materials from foreign lands to provide employment for millions. The ventilation, warming and draining of the habitations of the people, the bringing of water and light to their very doors, are his tasks. He invents and develops appliances by which distance is annihilated and the uttermost ends of the earth become our neighbors, for the written or spoken word. He mines into the earth for hidden treasures and converts them to the uses and needs of mankind.

There is, then, no branch of applied science with which the engineer should not be conversant. For his training we should lay a broad and solid foundation. He ought to have such a knowledge of his mother tongue as will enable him to express himself clearly and to commend his projects to those whom he expects to assist him, pecuniarily or otherwise, in carrying them out. He should have a sufficient knowledge of other languages to be able to avail himself of what may be found in foreign professional literature, as well as in English writings. In the present state of knowledge, no man has the time to investigate for himself from the beginning. He needs to take up the work where his predecessors have left it.

He should be well versed in science; he should be thoroughly acquainted with physics; he should know a considerable amount of chemistry; he should have some knowledge of astronomy, be well versed in mechanics and materials, and

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have ordinary, if not the higher, mathematics well at his command. He should be able to put his plans and designs upon paper accurately and neatly, and the designs should possess that appearance of fitness for their purpose which indicates the trained mind. There are besides all these, the special applications of science to one's chosen field.

It is, however, quite impracticable in the usual college course to cover all of this field in detail. The course must be limited in the main to the general foundation principles on which all specializing rests, with such branching out in the several directions as time will permit. The young graduate, when he has found his opening, perhaps in a direction he did not anticipate when at college, will be well prepared to pursue that particular line further in which his work lies. Experience and practice will teach him much, and his college training will lead him to know where to look for the information he desires.

It has been very forcibly said, I think, by Mr. Forney, that there are three kinds of knowledge, as there are three kinds of matter, solid, liquid and gaseous. The solid knowledge is that which a man gains by hard, practical experience. The student, when he goes out of college, has most of his knowledge in the liquid form, and considerable time is required to get it thoroughly solidified. Gaseous knowledge, perhaps of things that are not so, we have no use for; it is the kind that is possessed by the man called a *promoter*. Whether such knowledge could ever be solidified, is doubtful.

At the University of Michigan we have endeavored to carry out the preceding plan, so far as practicable with the time at our disposal. You will have to judge of our success by the results. I think we can turn to our graduates and feel reasonably well satisfied as to your verdict.

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As a considerable portion of the expense of publishing the Annual is paid from the advertising, we expect every member of the Michigan Engineering Society will, when other things are equal, favor those who favor us with their patronage, and use his influence to send orders their way. . . . . .

GEO. L. WELLS

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OUR OLD MEMBERS.

J. B. DAVIS.

There are no old members. This toast is a misapprehension. This company belongs to a class that never gets old. In the practice of the immortal virtues, they become immortal. Time does not obliterate their monuments, but establishes and confirms them. The rectitude of their conduct guides them in the straight and narrow way, that leads them smoothly on, to that oft discovered country from which no engineer has yet returned,—presumably because of having achieved the ability to work on higher lines. Peace to their footsteps, ever advancing those lines into the great hereafter,—attaining to rewards richly merited by devoted service in their honorable calling. As the great Artificer has seen fit to extend the lines of his handiwork in both the world of sense and the world of spirit, let us see to it that the lines of our handiwork unite these two worlds for us. We, as a society, already have our treasures in that other world,—likewise great treasures of manhood and fellowship in this.—and may we keep here such a store of treasures for those other members, whose journey of exploration has taken them across the boundary of sense, and past the landmarks of the material universe,—such treasures of memory, and devotion to the ideals of our profession, as shall ever keep them heartily with us.

We, who humbly learn the principles of our vocation in the infant school of the Almighty, and practice them diligently in his presence, never get old.

My thesis is proven.

There are no old members.

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CHAS. E. GREENE,
Dean of the Department of Engineering.
ANN ARBOR, MICH.

THE UNIVERSITY—ITS ENGINEERING FACULTY.

WM. APPLETON.

The University of Michigan is a big place, a large institution, kept up by a State which always has employed an able corps of scholarly men and to the best of our knowledge royal good fellows as teachers in all professions. In astronomy they scored high when they tried. In law, merciful saints deliver us from them unless they are on our side and we are not partial to law suits for steady diet anyhow. Should we get sick, the best known physicians pass at Ann Arbor. Should you get in a railroad smash-up or a steamboat blow-up, the Sawbones to eliminate superfluous pieces, glue the remainder together, and make you bether as new, he also was taught at the U. of M.; and in the final reckoning, I suppose some advice from D. D.'s from Ann Arbor will be useful to present as an introduction and will get favorable consideration from Peter. But all those slick worthies don't cut ice with us, we love them for their associations, only that and nothing more; it is to the men who are bone of our bone and flesh of our flesh we turn with feeling of pride, they are of us because they went out from us, if we are wounded they carry a scar, those are the men to make skilled men, in the profession of engineering, the teacher who has driven the stakes, whose shoulders have been sore by carrying the tripod, or whose face has been blackened by the smut from the lathe, otherwise well equipped, is the most desirable teacher. Thrice fortunate is the lad who desires to attain a proficiency in engineering who can, from the same man, and at the same time, have it taught in connection with its practical application, or if in the mechanical course in connection with the size, pitch and adaptability of a machine for its work, as it is taught there, it makes him in very truth a mechanic. No doubt those professors do get for students some lunkheads who no one could teach and some smart Alecks whose heads are swollen to the point of bursting with their own importance; either of these types of course discredit their teachers, but it is soon seen they are exceptions, and the fact remains that a youth who has graduated at the U. of M. is the next best thing to say he worked for Sears two years under his own eye on the F. & P. M. I don't know any better covering for a boy who feels the need of good clothing than Ann Arobr sheepskin, branded, the deeper the better, with the initials of "Chas. E. Greene," "J. B. Davis," "Chas. S. Denison," "Wm. H. Pettee," and last only by name our "M. E. Cooley."

Fellow members, hurrah for the U. of M. and our esteemed compeers, its hard working professors.

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THE COUNTY SURVEYOR.

A. J. TEED.

During the campaign a little while ago I wanted to make a very effective speech and spoke as a farmer, and now I shall be a country surveyor and speak from that standpoint, although I shall not say much about it. The country surveyor is no ordinary man. There is much about him very much like the country school teacher. You know the country school teacher boards around, and everywhere he goes he has poured into his ear the history of all the grievances and trials of the neighborhood that have happened in the last ten years. Again, the country surveyor is much like the country teacher with reference to the difficulties under which he has to do his work. The city teacher has a fine building, smooth blackboards, steam heated rooms, nice seats, and all that money and education can do to enable him to bring his scholars to perfection. But the country teacher is put in a log school house, with wooden benches, greasy blackboards, with box stove all worn out or perhaps no stove at all, and scholars of all grades, and yet he is expected to do as well by those scholars as the city teacher is by his. That is so with surveyors. The city engineer has his transit and his tables and trained assistants, and all that art and science can produce to enable him to do accurate work; but the country surveyor has an old compass, old chains, catches his assistants from any class of men that he has a chance, and traverses up and down hills, over logs, etc., and is expected to do just as accurate work as the city engineer. To illustrate some of the difficulties of the country surveyor, I will tell you of something that occurred some little time ago, and I want you to understand that everything I tell you is exactly true. I was working a line through a piece of woods, and I struck a cedar swamp. Now cedar swamps are not very desirable at the best; but in this case, fire had been through and burned the muck out, and there was cedar and hemlock and spruce and everything you could conceive of that had blown on the ground from ten to fifteen feet high and 80 rods long. This would have been enough to go through, but it was covered with about six inches of snow, and you couldn't tell whether the limbs would hold you or whether you would go headlong down through the brush. But that wasn't the whole of it. The fire had burned out, and the ground was cov-

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ered with water from two to eighteen inches deep, and this was covered with a half inch of ice and two inches of snow, so when you stepped on the ground you didn't know whether you would go down two inches or eighteen inches or whether you would go up or down, and yet we were expected to get our line through that swamp just as accurately as we did in places where it was all cleaned out.

In another way the country surveyor resembles the teacher; what he does is done for record. The teacher takes the plastic mind of the child and brings it up, and when it is turned out it is trained for all eternity. It is just so with the country surveyor; he sets the corner, and wherever he sets that, in nine cases out of ten, they are set forever. In the last 25 years of my experience I don't know of a single corner that I have proceeded legally to set,—I don't mean legally, but regularly to establish,—that has ever been changed. I don't mean to say they are right, but they were thought to be right, and they stand there until they have grown into the ground.

Now, the country surveyor is very often the county surveyor, and if you will permit me I will give a little account of my experience with the office of county surveyor, and it is a fact too. I will have to illustrate it by telling a story my father used to tell of a man by the name of Jones who had a great desire to own a certain bear skin; if he could only get that bear skin he wouldn't want anything else, and after a while by great efforts he got possession of the bear skin. He went home happy. Someone asked him what he was going to do with it. He replied, "It don't make any difference what I am going to do with it, I have got it." Well, he kept it a while and he couldn't see any particular use for it so he thought he would sell it; but he couldn't sell it, he couldn't find any one to buy it. He said, "Well, if I can't sell that bear skin I can give it away." He couldn't find any one that would take it, nobody to give it to. So he said, "If I cannot sell it nor give it away, I can lose it," so one morning he put it on his horse and started out and when he thought nobody saw him he slipped it off of his horse and went along feeling pretty happy, thinking he had got rid of the bearskin at last. He had not gone far when someone called "Here, Jones, here is your bear skin." Now, that is something like my experience with the office of county surveyor. Along in 1872 I thought if I could only be county surveyor I would not want anything else, would not even want to run for president or congressman. So I asked my father to go to the convention and see if he could get me nominated; I thought if I went my chance would not be very good. When it came time to nominate the county surveyor it was proposed that they

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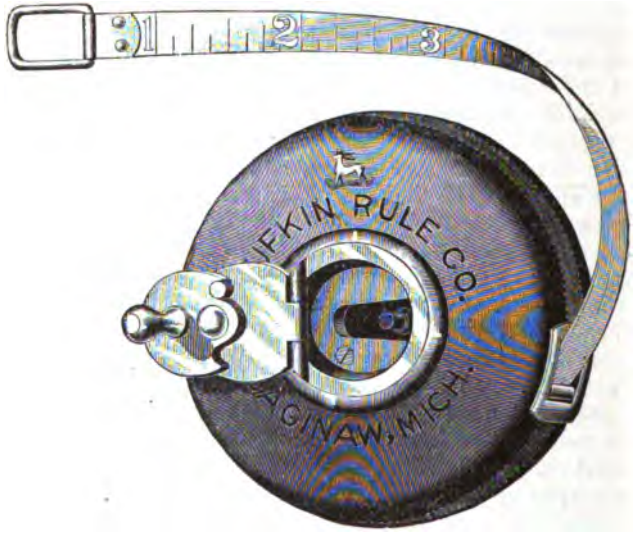

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nominate the present incumbent. Up jumped two or three politicians saying, "Don't do that, there is a new man in the field." That was just after the war when a soldier was a big gun, and some one said among other things, "He has been to the war, he has fought and bled for his country; I nominate A. J. Teed for county surveyor." Well, I was elected by a big majority because I had been a soldier. I had the office and as the time went on it began to seem to me that it was not so desirable after all. Finally I thought I ought to be able to sell out, but I couldn't find any one to sell to, nobody wanted to give anything. Well, I thought if I could not sell out I could give it away, and the next campaign I was off in the state of New York and they elected another man, and I thought I had got rid of the office; but the new man didn't qualify and I was appointed to act and went on with the office another eight years. Well, by and by I began to think if I could not sell that office and get anything out of it or give it away, I could get up a racket and get kicked out, so I thought I would try that. Well, I was nominated last fall as usual and after a while things were going on pretty smoothly and I began to holler for Bryan and I continued to holler for Bryan and I went out and made speeches. The politicians were after me pretty hot and I got out of that office. Well, I says, "I have got rid of that bear skin." Two or three days ago down comes the man who was elected county surveyor and he says, "Now, Mr. Teed, it wasn't right to turn you down that way; however, I will leave you the office——(Laughter was so loud I didn't catch the last of his sentence.)

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MICHIGAN, MY MICHIGAN.

MR. HUBBELL.

Mr. President, Ladies and Gentlemen: I apprehend that this new and original toast ought to be treated with a good deal of sentiment, and in that respect I realize my deficiency. I first thought that our president had examined one of those maps that we take so much pride in making, on which great blocks of land are marked off and painted red and the words "our own" written on it, and that it was intended to give me an opportunity to make an announcement in a literal sense to this toast, but I assure you that such an announcement would be premature.

I wish to say that I am proud of Michigan, proud of it because of the good moral character of its citizens, proud of it because of the high intelligence of its citizens, its just laws and model constitution. Now, perhaps some of you may take exceptions to that model constitution idea. But in the early seventies I was down in the state of Missouri, during the reconstruction period, when the old things were passing away, and among the new things she must have was a new constitution. As usual a great state convention was called, and some former resident of Michigan sent up here to Lansing and got a copy of the constitution of this State, and had the word "Missouri" inserted and presented it to the convention and it was adopted almost without exception. I was a little proud to say that I also came from Michigan. There was one thing that the Missouri constitution had attached to it, and that was the test oath of loyalty, and I was a little puzzled. I explained to my friends that we never had any earthly use for a test of loyalty up in Michigan.

I am proud of Michigan because of its varied products; it is not a State of one idea or of one party. California may produce more gold, Oregon and Colorado more silver, Minnesota and the Dakotas may grow more wheat, Iowa and Illinois more corn, and Missouri may raise more hogs and Kansas more wind; but Michigan excels them all in copper and iron and lumber and salt and potatoes and fruit, and is not a great deal behind in corn and wheat and other products. I am pretty well persuaded that we have plenty of hogs and are not entirely deficient in wind. Michigan has 1,600 miles of most beautiful water front, which is an advantage in the way of shipping these products.

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I have sometimes thought I would like to prepare a map of the United States. Upon that map the State of Michigan would come forth as a glorious American eagle. The southern peninsula would make the black body of the eagle, the upper peninsula would make the right wing, and for the left wing I would take the whole of Canada, if necessary. The balance of the United States would be about large enough for the bird to stand upon conveniently. Cuba would appear as the early worm about to be caught, and across the breast I would write in letters of gold, "Michigan, my Michigan."

THE ENGINEER THE SKILLFUL DIRECTOR OF UNSKILLED LABOR.

WM. B. SEARS.

Ladies and Gentlemen—In these days of pyrotechnics, modern wonders, modern finance, skillful chemists, learned doctors in law, medicine, and theology, and scientific engineers; with young women spinning gracefully on the cycle to school, store and office, doing the real business of the country, shod with pointed patent leather shoes; while the brothers are playing baseball, and breaking shins and bruising noses at football, and working the jaws in chewing gum and smoking the deadly cigarette, you will conclude before I am through that it was a waste of time and the height of folly for our learned and worthy president to ask an *out-of-date old fogy, like myself*, to respond to the toast, "Engineers, Skillful Educators of Unskilled Labor."

I shall not attempt any learned essay or sage advice, for, I am like Jolly Jack, the profane wag and teamster, who was hauling a load of pumpkins with an ox-team up a steep hill on a bright autumn day. Nearing the summit of the hill he met the village parson, going in the opposite direction, who, bowing and smiling, said, "Jack, *look behind!*" He did so, and discovered the tail board had bobbed up and out, and those pumpkins were rolling down the hill. Jack was overcome with astonishment and rage, as he stood gazing at the lost pumpkins, and the lost Christmas pie, but the parson, knowing how profane he was upon the least provocation, with a twinkle in his eye, said, "Why don't you swear?" Jack meekly replied, "Parson, I can't do the subject justice!" Now, ladies and gentlemen, perhaps I should stop right here, but as I have had some little experience with men in a business way for the

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past 44 years, and much to do with working and drilling raw recruits, full grown boys, some of them just out of school, occasionally filled with conceit and self-esteem, the first thing necessary is, to treat the young man in a frank, manly, open way, "to trust him," while at the same time find out who his associates are, and whether, when supplied with the funds, he pays promptly his *board-bill*, washerwoman and tailor. If he squanders his wages and fails to pay these parties, there is no hope for the future of that man; discharge him at once. If I find him honest in these matters, earnest, prompt, and diligent in the pursuit of every duty, then there is hope, because we can find out something more in detail about his habits and tastes, and suggest a line of reading and work that will fully absorb his time. *Keep him fully employed*, working him up to his full capacity during business hours. Don't keep him hanging around idle, waiting for something "to turn up," but, make him "turn up" and *turn over* something in the line of useful work every day. By pursuing with diligence and care this method of work (and few young men appreciate how the master is burdened with work and cares, and has the patience to do this), if he is in love with his business or profession, he will soon develop into a useful aid; then, advance his pay and promote him according to his capacity and moral worth. If you find upon *intimate* acquaintance, he is not strictly honest and faithful to every trust, dispose of him as soon as practicable, and "try another." Many times we do society and the State a positive damage by advancing the knowledge and material interests of the man we know to be *shrewd* and *smart*, but, who is at the same time, selfish and corrupt.

Witness the rascals today, in the capital city of the State, putting down four and one-half inches of concrete and getting paid for six inches, right under the eyes and noses of political bosses, with untrained, incompetent and, no doubt, dishonest inspectors. Many of our college boys, waiting around hankering for something to do, if they manifested the same pluck and disposition to engage in useful work as they do to play ball, might begin here at the bottom of the ladder, "learn to make good concrete and see it honestly applied," and stepping by degrees from the bottom to the top of the ladder, greatly improve the status of municipal engineering. This is the shortest and best route to success, boys, in that line of work. Ten years spent, five in the field, and five in the office, at a very moderate salary in the beginning, to make yourselves thoroughly familiar with all the problems and details of municipal work, would qualify many of you for, and place you in the positions now occupied by political bosses that rob and disgust the

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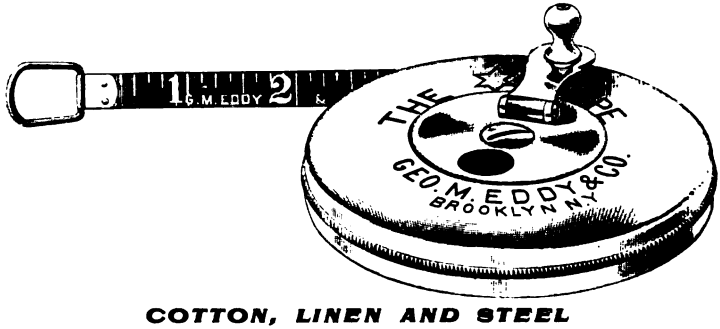

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taxpayers. You must begin this work right away, boys, to save your town, the State and the country from the domination of the political boss, and the incompetent bribe-giver and bribe-taker. It is unfortunate that for the past 30 years, our government, both state and national, has been run almost wholly in the interest of "special classes," legalized plunderers who purchase the small pettifogging attorneys from city and country, and cause them to enact laws that systematically rob the real producers of wealth, the farmers, and the laboring masses. Every engineer in charge of public work should use his influence to checkmate and defeat the organized steals brought forward by these rascals, and upon all occasions discharge his duties faithfully and honestly to secure economy and permanent results at a minimum of cost. If we all labor earnestly along these lines, we shall soon be able to modify and improve existing conditions. For the young man just entering upon the stage of action, there is a broad field for the display of every talent, for all the technical, scientific and practical knowledge that any mind can grasp. With our magnificent area of arable land, boundless natural resources, in field, mine and forest, grand rivers extending from center to sea and multiplied railways, that eclipse the world for safety and speed in the distribution of passengers and freight; there is certainly here something to be done by the young, brave, honest, thoroughly equipped engineer, to bring fame and fortune by serving his country and mankind. With highways in a crude state, undrained and impassable for loaded teams months in the year, undrained farms and swamps breeding pestilential vapors, the large cities dumping their waste into the sea, the rivers and lakes, impoverishing the soil and poisoning the water, the small towns and villages with that barbarous receptacle for night soil, dripping into the well two rods away breeding malaria, typhoid and diphtheria, crowded tenement houses in the city slums, festering with filth and moral poison; to be wiped out and destroyed, and instead of these, *healthy*, well-arranged, sanitary homes erected for the working classes. An abundance of clean, *pure water to supply the wants of the people*, dams for controlling destructive spring floods and storage reservoirs for irrigation, the use of electricity and compressed air for power and light, with gas for heating and cooking. To utilize God's green earth and all *these agencies* for a better social and political economy. The young engineer, civil and mechanical, must take a leading part, and show the multitude "how" and when to *act*.

Now, ladies and gentlemen, enough of my stale moralizing. I have a story to recite which may revive pleasant memories of

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"Auld Lang Syne" to the older members, and if the younger ones can imitate the inventor, Charles C. Leonard, and produce something that will destroy the demagogue "the bribe-giver and bribe-taker" and aid our worthy Governor to rid the State of these rascals and institute some needed reforms, he will, no doubt, reap a rich reward.

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WASHINGTON, D. C., March 10, 1895.

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Dear Sir: In my work at the office I have to write replies to County Surveyors' inquiries upon all sorts of cases. I was much pleased to receive a copy of the new edition of your work on Surveying. I find daily occasion to refer to it at my desk and have given it many a strong commendation to others. It has been shown to the six or eight gentlemen forming this division with my unqualified opinion that *it is the most intelligent and complete summary of all that a practical surveyor should know or should have in his pocket for ready use, of all the books I have seen.* The directions regarding work on old lines and identifying old corners are not equalled elsewhere. Major Shinn was glad to see how copiously you had used the latest features of the new manual that he compiled and revised, even his ingenious table at the last of your book. With many thanks for the book, I am

Yours truly,

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all directions with lightning rapidity and the adversaries within six feet of him are torn to shreds! Fresh battalions come to the scratch only to meet a like fate, and in the morning several bushels of hair, fiddle-strings and toe-nails is all that is seen, while the owner proceeds to wind the iron cat up and set him again. Only a few pleasant evenings are needed to clean out a common sized country town of its sleep-disturbers.

"We understand the inventor will make a proposition next week to the common council to depopulate the city of cats for a moderate sum. We do not intend to endorse any invention or article unless we know it will perform all that it is claimed to do, and therefore we have not been as explicit in our description as we might have been; but the principle is a good one, and we hope to see every house in the city surmounted with a sheet-iron cat as soon as they are offered for sale, which will be about April 1st, the inventor and patentee informs us."

Now, gentlemen, I have given you the hint, make the new invention applicable to pestiferous men, instead of cats, and help the Governor out.

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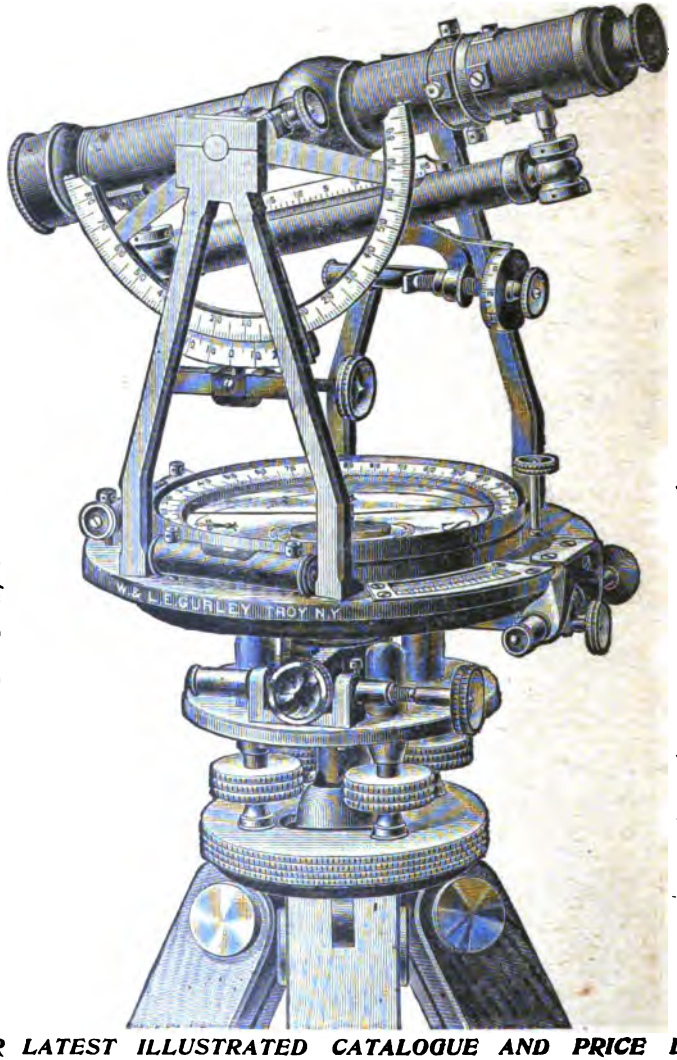

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